SCIENTIFIC AMERICAN SUPPLEMENT No. 83

Scientific American Supplement, Vol. IV, No. 83.
Scientific American, established 1845.

NEW YORK, AUGUST 4, 1877.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

SPRUCE CREEK TUNNEL.

OUR engraving illustrates the entrance to the Spruce Creek Tunnel, on the Pennsylvania Railway. The width of the tunnel is 21 ft. 10 in. at the rails, 23 ft. at springing. Total height, 18 ft. 8 in. The arch is circular.

[SCRIBNER'S MONTHLY.]

A RAILROAD IN THE CLOUDS.

By J. EGLINTON MONTGOMERY.

A VISIT to Peru rewards the traveler with an extensive field of study and pleasure, in the beauty and grandeur of its scenery, the variety of its climates and productions, the romance of its history, and in the archæological remains that represent its very ancient civilization. When to these attractions is added one of the essential elements of modern progress—easy railroad communication in its highest development—it becomes, for our western world, a land of unequaled interest.

The surface of the country is itself characterized by great variety. A strip of sandy waste, traversed by streams and fertile valleys, extends from the Pacific Ocean to the mountains that form a double barrier between the coast and the Montaña. This barrier, called the Sierra, consists of two ranges, the Western, or Maritime Cordillera, and the Andes, or Eastern Cordillera. Between them are transverse branches, luxuriant tropical valleys, lofty plateaus, and table lands of great extent, where the Sierra widens out, as it does about Lake Titicaca. The Montaña comprises two thirds of the Peruvian territory, and is a tropical region teeming with animal and vegetable life, lying wholly in the basin of the Amazon.

The line of the Calláo, Lima, and Oroya Railroad stretches across the coast, and a greater portion of the Sierra. It starts, as its name specifies, from the very shores of the Pacific, at Calláo, the port of Lima, and the chief *entrepot* of Peru. It follows the valley of the Rimac, upon a continuously ascending grade, to the source of that stream, and crosses the summit of the Andes through a tunnel—the Galera—at a height of 15,645 feet above the level of the sea. Thence, striking the head waters of the Rio Yauli, one of the feeders of the Amazon, it descends along its valley to Oroya, where terminates the first part of the great road by which it has been proposed to connect the waters of the Pacific Ocean and the Amazon River, notwithstanding the formidable obstacles that intervene.

We take the train at Lima for our long-anticipated and deeply interesting journey, and, following the left bank of the Rimac, find ourselves traveling through a valley that averages about three miles in width, until we reach Chosica, where the converging lines of the Cordillera compress it to a width of little more than 1,000 feet. Owing to the admirable system of irrigation long practised in Peru, the land is remarkably fertile, and produces fruits and cereals in such abundance as to surprise the traveler, since the region is subject to frequent volcanic disturbance. The road follows the center of the valley, amid fields green with corn, and sugar-cane, and the nutritious lucern or alfalfa—a species of clover extensively and profitably cultivated.

Between Lima and Chosica very little difficulty was experienced in the construction of the road, the principal requirement being a conformity to the gradual rise of the valley, which was accomplished by the adoption of a parallel grade, amounting in some cases to two and a half per cent., or 125 feet to the mile.

We are told that Chosica is the most interesting place in the neighborhood of Lima for archæological researches; but the train allows no time for investigation, and we soon exchange the pastoral and picturesque valley for the barren and precipitous mountain pass. Green fields are left behind, and the thorny cactus already begins to dot the sides of the declivities. The track takes the tortuous course of the Rimac, on whose edge we pursue a darkening defile. Here the four per cent. grade begins, and with it regular up-hill work.

As we pass the village of San Pedro de Mama, roofless adobe huts and catacombs in the sides of volcanic ridges are the only remains of a once thriving population. The narrow valley of Eulalia then branches to the left, flanked by lofty natural walls, and open only to a vertical sun, and yet it supplies the market of Lima with almost every variety of tropical fruit. About this point, the road passes through "the Italian cut," named for seventeen wandering Romans, all of whom died in the process of its construction. Five or six miles beyond Chosica we cross the first of the iron bridges—Cupiche—that span the gorge, and we follow the curvatures of the river at a grade of four per cent., or 211 feet per mile. The road conforms with persistent regularity to the contour of the mountains, crossing and recrossing the Rimac, and passing in its course a heavy deposit of gravelly talc, extensively used in paving the streets of Lima. Thence the valley widens to Cocachacra, displaying miniature fields of corn and alfalfa, and gladdening the eyes with an oasis in the midst of this rocky fastness—until converging mountains shadow the valley, hem in the impetuous river, to recede again and encircle a bit of verdure, where the Seco, a mountain stream, empties into the Rimac. Looking forward from this point, the course of the road can be distinctly traced, winding along the right declivities of the ravine, until it approaches tunnel No. 1, discernible four and a half miles off, at a height of 600 feet above the valley, as a little dark spot. Seen from such a distance, a train of cars appears like a great serpent gliding along the face of the rocks that are piled one upon another to the very summit of vanishing heights.

The next station, San Bartolome, thirty-nine miles from Lima, is 4,910 feet above the sea—an unparalleled ascent for that distance.

Here occurs the first of the retrograde developments rendered necessary by the increasing rise in the valley. The line takes the form of a V, and receding upon an ascending grade reaches the elevated plateau where stagnates the forbidding-looking village of San Bartolomé. Thence crossing and recrossing the Seco, it makes two complete detours and ascends on the opposite side, past a point overlooking the station of San Bartolomé, whence a vista opens into scenery somewhat Alpine in its character. Yet the road still clings to the rugged sides of the towering ridges, passes through two tunnels, and crosses a deep mountain gorge on the famous Verrugas viaduct. This structure is a very elegant and artistic specimen of ironwork. It is of the Fink type of truss, 575 feet in length, supported upon three piers of wrought iron columns or rods, respectively 145, 252, and 189 ft. in height. It is the highest bridge in the world. And although at a distance it appears too delicate for the practical work of a railroad, it has been found on being subjected to the severest tests capable of bearing the heaviest weight without any sensible vibration. At the base of the central pier are huge pits, which treasure-seekers have vainly excavated in the hope of finding the buried riches of the Incas, concealed, as it was supposed, from the rapacity of their Spanish conquerors.

Leaving this fairy like viaduct behind us, the road pierces two projecting bluffs by tunnels Nos. 3 and 4. The former is approached by a cut in the upper side, about 400 feet in height, against the face of a precipice (Cuesta Blanca) that rises 1,000 feet in the air. Along this entire portion of the route, the rails wind through a great labyrinth of detached rocks and bowlders, apparently so delicately poised that the most trifling convulsion might at any moment precipitate them into the valley below. Nevertheless, the road pursues its course through deep cuts, in spite of all obstacles, shaping itself to the outline of the mountains, and ascending with unfaltering steadiness from height to height, at a grade of 210 ft. per mile.

At and above Surco, the valley occasionally expands into little ovals of bottom-land that afford space for the cultivation of a diminutive field or an occasional flower, sadly solitary in this volcanic region. A mile further on we cross the Rimac by the Ucenta bridge, from which there is a view of tunnels Nos. 5, 6, and 7. The last two are perched directly above No. 5, and appear like dark drifts or openings in a coal mine. Higher up the valley, beyond the third tunnel, may be seen the delicate outline of the Challapa bridge, spanning a deep chasm as if suspended in mid-air. All these interesting points are speedily reached by two complete detours. The first crosses the river by the Mayuyaca bridge, and describes an entire semicircle upon a 14° curve of 376 ft. radius; thence passing southward for about a mile to Sacrape.

Here the second detour returns the line on its course to the two tunnels which we previously saw from below; and when it emerges from them, it pushes on, crossing Challapa Gorge on a beautiful bridge, 160 feet high, which a short time before had appeared to us as an aerial structure.

Thence we wind along the hills to Matucana, an important station thirty-five miles from Lima, and 7,788 feet above the level of Calláo Bay. The Cordilleras tower above the primitive little town, to the height of from 3,000 to 4,000 feet. It shelters, it is said, a thousand inhabitants, and is the gathering-place of as many more "children of the mist," who flock from the neighboring mountains on the occasion of every excitement, festival, or anniversary. They are exclusively of the Indian type peculiar to this part of South America, and are by no means an attractive race. In person, they are short and stout, and have a very sinister expression of countenance. They are sharp and unscrupulous in their business transactions, irascible and vindictive in temper, uninteresting and indifferent in their manner to strangers, and, withal, affect an air of stolid superiority as if they were the veritable descendants of the Incas, and were surrounded by all the fabulous splendors of their ancestors. Nevertheless, they live in the usual adobe huts only one story high, whose slanting roofs are thatched with straw; and their wives, with papooses strapped to their backs, superintend the labors of

SPRUCE CREEK TUNNEL, PENNSYLVANIA RAILROAD.

the house and garden. The principal men or hidalgos, in wide sombreros and ponchos of *vicuña* or other skins, ride about on sure-footed little horses or donkeys, that amble in a manner peculiar to the animals of Chili and Peru. Add these figures to the ordinary accompaniments of a railway station, such as busy officials, waiting travelers, an arriving or departing train, and the village of Matucana is described.

Borne away from the fumes and bustle of the unattractive little town, we find that impressive as has been the scenery through which we have passed, it has been but the introductory pageant to the gloomy majesty and savagery of the Andes. Matucana is twenty-seven miles, in a direct line, to the highest point of the Andes through which the railroad passes. Snow begins to touch the heights with its white mantle, and so wild and awe inspiring are the scenes that open before us, that the country we have left behind dwells in our memory as cultivated and habitable.

Words fail us to express our admiration of the skill and courage which, having already accomplished such wonders, ventures to attempt difficulties truly appalling; for the higher we ascend the more formidable become the obstacles which oppose the advance of the locomotive.

A short distance above Matucana, we skirt the immense landslide which occurred about two years ago, causing great damage and loss of life, particularly among mules and llamas. It is estimated that millions of tons of earth and rock swept down from the mountains into the valley beneath, damming up the torrent-like Rimac, which formed a lake of considerable depth, and threatened disaster to the country below, and even to Lima. But a sluice was gradually opened, which the river has sufficiently enlarged to enable it to discharge its waters; and although the lake remains, its depth is reduced, and it has ceased to cause apprehensions of danger. Here above us, as well as elsewhere on the line of the railroad, are the remains of well constructed terraces on the sides of the mountains, rising like tiers in an amphitheater, and conforming closely to the contour of the ground. So enormous are some of the stones of which they are composed, that one is at a loss to conjecture by what mechanical contrivance they were brought to their present position. Peru is said to have had, at one time, 12,000,000 of inhabitants where now there are not more than 2,500,000. Numerous indeed must have been a population which was driven to cultivate every available spot on the isolated and barren heights of these Andean masses that now afford nourishment only for the cactus. Not a blade of grass nor a shrub is visible as we pass through this desolate region.

Since we left "the lower V," a distance of four miles, the road has passed through six tunnels, three of which succeeded one another so rapidly as to seem continuous, with an occasional shaft opening to the sky. One of them is built upon a reverse curve, and forms an elongated S. Beyond them, a scene of terrible grandeur greets us—rugged mountains in the distance lift their snow-capped heads so high as to appear to support the blue dome above them; while in the immediate foreground porphyritic cliffs rise on every side many hundreds of feet in the air as if to baffle any attempt at escape. But the presiding genius who has conducted us thus far does not fail us now, and we work our way out of every stronghold in which we are entrapped. Again we cross the Rimac, near its junction with the De Viso, and travel along the opposite side of our familiar stream, until we ascend by another zigzag of three almost parallel lines to tunnel No. 14. Here, looking back upon the exploit just accomplished, the traveler exclaims: "What next?" What but fresh surprises—new Cyclopean labors—gorges and chasms opening around us to invisible depths, and beyond—

> "Alps, Andes, Himalaya,
> Defiant seemed to stand,
> Each range a giant slayer
> Of steps twixt land and land."

From this point to Anchi, the laying out and construction of the road was attended with immense difficulties. In many places the bluffs were so steep as to render it necessary to lower the laborers by ropes from benches or shelves above, in order that they might cut out standing-places from which to commence work.

Engineers were often compelled to triangulate from the opposite side to mark out the course of the road; while in one case, they and their men were conveyed across a valley on wire ropes, suspended some hundred feet in the air between two cliffs.

From Tambo de Viso to Rio Blanco, the present terminus of the rail, and only fifteen miles distant, the road passes through twenty-two tunnels. In some cases the work has been done by the diamond drill, the rock often being so hard as to score glass. Tunnels Nos. 18 and 19 are separated by a short bridge that spans a chasm. Along this portion of the route the dark line of the road may be traced, now on the face of a cliff, now disappearing behind a projecting mass or in a tunnel, but always ascending under the most adverse circumstances. Between tunnels 19 and 22 formidable obstacles opposed its construction. The road-bed, as usual, conforms closely to the configuration of the ridges, crosses the Parac River—here a headlong torrent, emptying into the Rimac from the eastward,—and continues on to Tamboraque, along the Rimac. Then another retrograde development becomes necessary, and the road, being reversed, returns along the bank of the Rimac to the valley of the Parac; ascends that branch for half a mile to another switch, and returns the second time to the Rimac, high above the lower line, passing through two tunnels, one almost directly above the other. The view from the spur which divides the two valleys is superb in the extreme, and affords an extended panorama of Andean scenery, seldom seen and rarely equaled. Presently we look down upon the primitive little village of San Mateo, nestling in the valley under the shelter of lofty mountains, and in general character very much resembling Matucana.

For a short stretch of two miles beyond San Mateo, the mountains approach each other so closely, and tunnels follow in such quick succession, that light and darkness are very equally divided. Between San Mateo and Anchi we cross a terrible gorge called "Los Infernillos,"* where the river passes through two walls of red porphyry that rise perpendicularly to a height of from 1,000 to 1,500 feet. These form two reverse quadrants, and the Rimac—now a mountain torrent—plunges, roaring, leaping, and foaming into the abyss.

> "This, as it frothed by, might have been a bath
> For the fiend's glowing hoof."

The bridge that spans the chasm is 160 feet high, but masses of rock thrown down during its construction have lessened its apparent height. We emerge from a tunnel to cross the "puente de los Infernillos," and we depart in like manner. Seen from the contracted valley beneath, a train of cars must appear to spring mysteriously and suddenly over the graceful little structure, and to disappear like a thing of will and might, burrowing through the very heart of the mountains. The accompanying diagram will furnish a profile of the country at this point, and give a faint idea of the marvelous resources in engineering required to accomplish such tasks as the nature of its formation imposes. The three tunnels, Nos. 30, 31 and 32, are so close together as to be almost one. After passing through No. 32, the road continues to ascend by another zigzag, rendered necessary by the very much increased grade of the valley of the Rimac just below Anchi, where it is spanned by a bridge 107 feet above the stream.

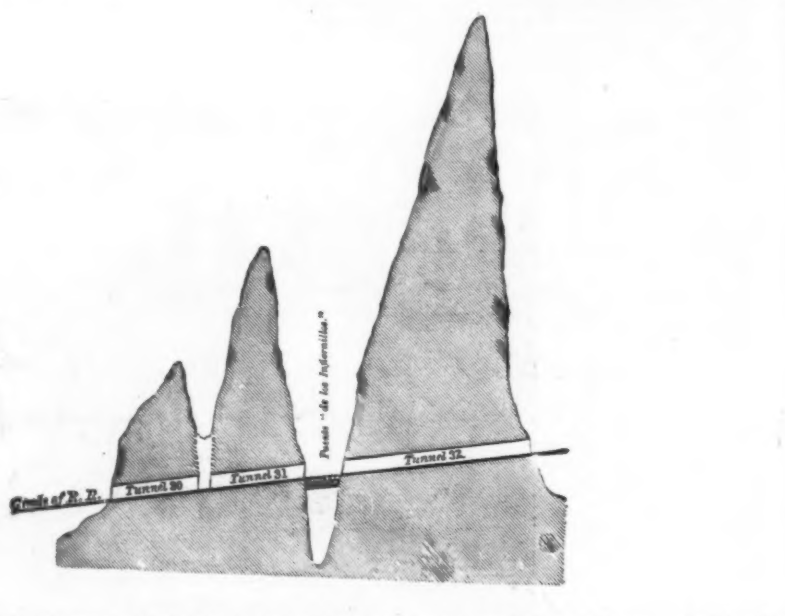
Anchi is principally a railroad settlement, situated at the junction of the Rimac and the Rio Blanco. It is 74 miles from Lima, 11,300 feet above tide-water, and lies in the very gorge of the mountains. Even from this elevated spot the snow-clad Andes appear as high above us as they did some distance below, and we find that there is still an ascent to be made of 4,000 feet. This little collection of shanties is a mile below Rio Blanco, to and from which point freight and passenger cars run daily with regularity and dispatch. Here we begin to experience some of the disagreeable physical effects of the rarified air of great altitudes, of which the *soroché* is the most painful and dangerous. It is a congestion of the lungs, and is accompanied by a sensation somewhat resembling sea sickness, besides pains in the back, the eyes and ears, vertigo, and general debility. Persons of a full habit are the greatest sufferers, but those who, like Cassius, are of "a lean and hungry look," escape with less inconvenience.

The trip by rail is now at an end, the road not being in working order beyond this point. We pass a night of refreshing sleep at Anchi, under seven blankets, and are prepared to complete the journey the next morning on horseback, in company with the resident engineer, Mr. Tobias, Dr. Ward, the physician, and Lieutenant Derby, U. S. N., our fellow-travelers from Lima. The distance by rail to the summit is twenty-one miles, but it is greatly reduced by avoiding the switches and pursuing the more direct mule-paths. In this short distance are twenty-two tunnels. Much of the heaviest work and the longest tunnels are so far advanced toward completion as to require but a short time to put them in order for travel.

columns in half relief—some almost upright, some aslant, while through their upper walls jagged and irregular masses of dark igneous rock have been forced into violent prominence. They rise like a succession of natural fortifications around the valley, and so unscalable are they, and so securely does the valley appear to be inclosed, that no other mode of egress seems possible than that of the condor. But the fortress is undermined, and escape is effected through seven tunnels, all in the space of a mile. From this point to the dividing crest of the Andes the line of the road is often lost to sight amid desolate masses of snow and ice.

Very heavy work had to be done and great obstacles overcome; but still it pushes on, rising higher and higher, winding around the fountain-springs of the Rimac, its companion from the ocean, until it finally reaches the dreary summit of the Andes, and enters the Galera, or "tuñel de la Cima," as it is styled by the Peruvians. This tunnel is 1,173 meters, or 3,487 feet in length, and enters the mountain about 680 feet beneath the apex of an undulation lying between Mount Meiggs on the right and two gigantic peaks on the left. It is ninety-seven miles from Lima, and has an altitude above the sea of 15,645 feet, being only 136 feet below the very top of Mont Blanc.* Although not completed, it is open throughout its entire length, and could soon be put in condition for travel. Its construction was attended with unparalleled difficulties, demanding unceasing effort and the greatest powers of human endurance. All the machinery for boring and working the approaches came from the workshops of Lima, and were brought on the backs of mules from the terminus of the rail. In the progress of the tunnel every step was impeded by snow-water percolating from above, often bursting through seams and driving the peons from their work. And, although the most hardy serranos were employed, and those inured to the painful effects of a very rarified atmosphere, yet even they were frequently disheartened by their many trials. Thus, this tunnel of the summit is the monument of a heroic determination which has wrought victoriously, through eternal winter and desolation, to gain a trans-Andean world laden with the ungathered fruits of perpetual summer.

Mount Meiggs, named in honor of the distinguished contractor, Mr. Henry Meiggs, is a short distance south of the tunnel. It is 17,500 feet about the sea, and from its conical peak float the American and Peruvian flags. A small observatory, in which the barometer indicates the pressure of the atmosphere to be 17 inches, and the thermometer stands



At Anchi the valley of the Rimac trends sharply to the northward, and the line of the road follows the Rio Blanco for a mile and a half, then makes a full detour, and returns to the left bank of the Rimac, which it pursues, passing through seven tunnels to the village of Chicla, where occurs the greatest development on the entire route. No less than five almost parallel lines are visible from any point of the valley—three on one side and two on the other of opposite mountains—while the greatest distance between any two of them is scarcely five hundred feet. This remarkable zigzag of the road crosses the Rimac on a sharp detour, thence returning to the right bank of the stream for a short distance to a switch, where it is directed once more to the northward for a while; again crosses the Rimac on a short curve, retraces its course along the left bank below Chicla to a second switch, which returns it on its direct course on the same side, and above the other line, to Casapalca, seven miles from Anchi, and a point at which the road-bed attains an elevation of 13,615 feet above the sea. Between Chicla and Casapalca we pass several half-ruined villages, resembling those already described, with irregular rows of wretched mud huts just as filthy, and inhabitants equally ignorant and indifferent. They belong to the most enervated tribe of South American Indians, and subsist upon the little the rocky earth yields to their indolent efforts.

Through this section of the road the solitude of the mountains is frequently broken by droves of llamas, or South American camels, and long trains of mules and donkeys laden with fruit and eggs. Flocks of condors soar above them, awaiting a repast on some overburdened and disabled beast. A few miles above Casapalca, and nearly opposite Anterangra, the narrow valley of the Chin Chan opens suddenly from the north, and divides two towering ridges crested with perpetual snow. From this point a number of experimental lines were run; but the one selected crosses the Rimac and advances up to the Chin Chan for two miles and a half, where, making a sharp detour, it returns above the first line, and re-appears on the right bank of the Rimac, 1,000 feet above the bed of the valley. This great elevation affords a view of impressive grandeur. On one side conical snow-peaks, glistening under the rays of a tropical sun, raise their impassive fronts, and, wrapped in white mantles, show no traces of the agitations that have marked the nearer ridges. These, as if they had been plastic masses, are moulded along their base into a continuous line of rude

at the freezing point, permits the traveler to contemplate the surrounding scene at his leisure. Towering snow-peaks encircle an icy plateau, with no opening between them, except where the Rimac has forced its way. A sky of the deepest blue throws into bold relief these "giants of frost and snow," fit sentinels between land and sky, and as yet undisputed possessors of their dreary abode. We say as yet undisputed, for in view of the journey we have just accomplished, it would be folly to feel secure of any uninvaded territory. The trip has seemed a dream of wonder and enchantment; and having arrived safely at its end, we already begin to sigh for new powers of locomotion—unattained aerial heights—fresh prodigies of skill! But obviously, such travels must be delayed for a time, and we return to our still extraordinary bit of *terra firma* to sketch the remainder of the route, and some circumstances and results connected with the great Andean highway.

From the eastern outlet of the Galera the line descends to Oroya at a moderate grade, and without encountering any formidable difficulties. Throughout the latter portion of the road, including the section between Rio Blanco and the summit, a distance of 53 miles, a considerable amount of grading has been done, while much of the track is in such an advanced state as to require but little additional labor to put it in condition for travel. At present the work is suspended in consequence of the depressed condition of the Peruvian finances. Oroya is situated at the junction of the Yauli and Jauja rivers. It is 12,178 feet above the sea, and 129 miles from Lima; and here the contract for the road terminates. From this place to the nearest navigable point on the Amazon is 250 miles. When the connecting road shall be completed it is estimated that the traveler landing at Callão can reach a steamer on the Amazon in from 20 to 30 hours; thence to Para is about 2,000 miles. A week, or even less perhaps, of travel down the mighty river, through its magnificent forests, and the Atlantic is under his keel! From Oroya may be run two branch lines—one northward, for which Mr. Meiggs is already in treaty with the government, namely, to the Cerro de Pasco, the richest silver mines in the world; and the other running south to Jauja, whose delightful climate would make it a favorite resort for invalids.

(*To be continued.*)

* Little Hells.

* Mont Blanc is 15,781 feet above the sea, according to Corabœuf.

RACK-RAIL RAILWAYS.

THE idea of employing for the working of steep gradients a locomotive provided with toothed gear which engages with a rack laid between the ordinary rails is a very old one, and as long ago as 1852 it was carried into practical effect in the United States, Messrs. Baldwin, of Philadelphia, having in that year built some "rack-rail" engines for working the Madison incline—a gradient of 1 in 16½—on the Jeffersonville, Madison, and Indianapolis Railway. These engines were constructed on plans patented by Mr. A. Cathcart, and they were regularly employed in working the traffic of the incline in question until July, 1868, when Mr. Reuben Wells, the locomotive superintendent of the line, substituted for them an exceptionally heavy and powerful tank engine depending on its own weight for adhesion. In 1857, too, Mr. Sylvester Marsh, of Chicago, applied to the State of New Hampshire for a charter for the construction of a line up Mount Washington, in the White Mountains, but his scheme was not received with favor, and it was not until 1869 that the line was really completed and opened for passenger traffic. Mr. Marsh's scheme was an exceedingly bold one, but it has been thoroughly successful. The line is about three miles in length, and has an average gradient of 1,300 ft. per mile, or very nearly 1 in 4, while its maximum gradient is 1 in 3; and the engine, which weighs about 7 tons, pushes up before it a passenger carriage weighing about 4 tons, the time occupied in the ascent being about one hour.

The Mount Washington Railway was designed as a passenger railway for transporting the great throng of summer visitors to the summit of Mount Washington, some 6,000 ft. above sea level, and it may, we think, be fairly considered to be the first railway of its class. In Europe, however, the plan of employing a rack for mountain railways has been independently worked out by M. Riggenbach, whose persistent advocacy of the system has led to its adoption in a number of instances, there being now eight rack railways on the continent either working or in process of construction. Respecting these lines and the introduction of the rack-rail system by M. Riggenbach, we propose to have a few words to say.

M. Riggenbach, who was for twenty years the locomotive superintendent of the Central Railway of Switzerland, had during that time under his charge the working of the line passing under the Hauenstein between Basle and Olten. On this line there is a very steep ascent, commencing at the village of Sissach and extending about six miles with a gradient of 21 per 1,000, or 1 in 47·6, to Laufelfingen, where the main tunnel begins. At the very entrance to the tunnel a rising gradient of 26 per 1,000, or 1 in 38·47, commences and continues to the bridge over the Aar, near the Olten station. The length of this steeper portion of the ascent is about 5¼ miles, of which 1½ miles are in the tunnel and the rest in the open. From some years' experience M. Riggenbach found that the powerful six-coupled engines employed on this section of the line, although capable of drawing a load of 120 tons up the gradient of 1 in 38·47 in the open, could only take about 90 tons up the same gradient through the tunnel, in consequence of the rails in the latter being continually in a moist and slippery state. In fact, it was necessary to use sand uninterruptedly in order to obtain sufficient adhesion. This state of affairs, causing as it did a reduction of 25 per cent. in the effective work done by the engines, led M. Riggenbach to turn his attention to modes of rendering locomotives independent of ordinary adhesion when working steep gradients, and to thus enable them to work steeper inclines than can be dealt with in the ordinary way, and eventually he came to the conclusion that the rack-rail afforded the best means of attaining the desired end. After trying various models, M. Riggenbach, in 1862, patented an improved mode of constructing rack-rails and locomotives with toothed gear working into such rails, the well known firm of Andre Kœchlin & Co., of Mulhouse, taking the necessary steps to secure the French patent. Having proceeded so far, M. Riggenbach tried hard to get an opportunity to make a steep gradient railway on this rack-rail system, and for years he—to use his own words—"traveled with his models like a Savoyard with his marmot" to attend any meetings of engineers or others to whom it was desirable that his plans should be explained.

At length, in 1869, he found amongst his friends at Basle some supporters who, rather to give him pleasure than with any idea of starting a profitable business, procured him the means for the construction of the railway from Witznau on Lake Lucerne to the summit of the Rigi, a total rise of 3,937 ft. in a distance of about 3¾ miles. This line, which was commenced in November, 1869, was opened for traffic in May, 1871, and the results obtained with it have been most satisfactory. The line is worked by the locomotives of the pattern shown by the annexed Fig. 1, the first six of these engines having been built at the works of the Central Swiss Railway Company, at Olten, under the direction of M. Riggenbach, while the rack-rails, carriages, trucks, etc., were also made at the same works. The gradients on the line vary from 1 in 5·56 to 1 in 4, while the curves are all of 180 meters (590½ ft.) radius. The carrying rails are of the Vignoles section, weighing 35 lbs. per yard, and are laid to the ordinary gauge of 4 ft. 8½ in., while between them is fixed the rack-rail formed of two 4¾ in. by 2¾ in. channel irons connected by wrought iron teeth. The locomotives, which weigh about 12½ tons, have cylinders 10¾ in. in diameter, with 15¾ in. stroke, and the crankshaft is so geared that it makes 3·07 revolutions for each revolution of the driving axle: while the latter has carrying wheels 21 in. in diameter, and has keyed on its center a wheel of the same diameter at the pitch line gearing into the rack-rail. The engine pushes up before it a single passenger carriage weighing 4 tons and carrying 54 passengers.

In 1872, M. Riggenbach, seeing the technical and financial success of the Rigi Railway, left the Central Railway of Switzerland, and devoted himself entirely to the construction of mountain lines; but at that time it was not proposed to start independent works, and he gave to the Schweizerische Locomotiv und Maschinenfabrik, at Winterthur, orders on behalf of the Rigi Railway Company, or on account of the Société Internationale des Chemins de Fer de Montagne, for locomotives for the following lines: Rigi Railway; Kahlenberg Railway, Vienna; and Schwabenberg Railway, Pesth. These three types of locomotives are represented by the annexed diagrams, Figs. 1, 2, and 3 respectively, while a few weeks ago we gave a detailed description of those for the Kahlenberg line.

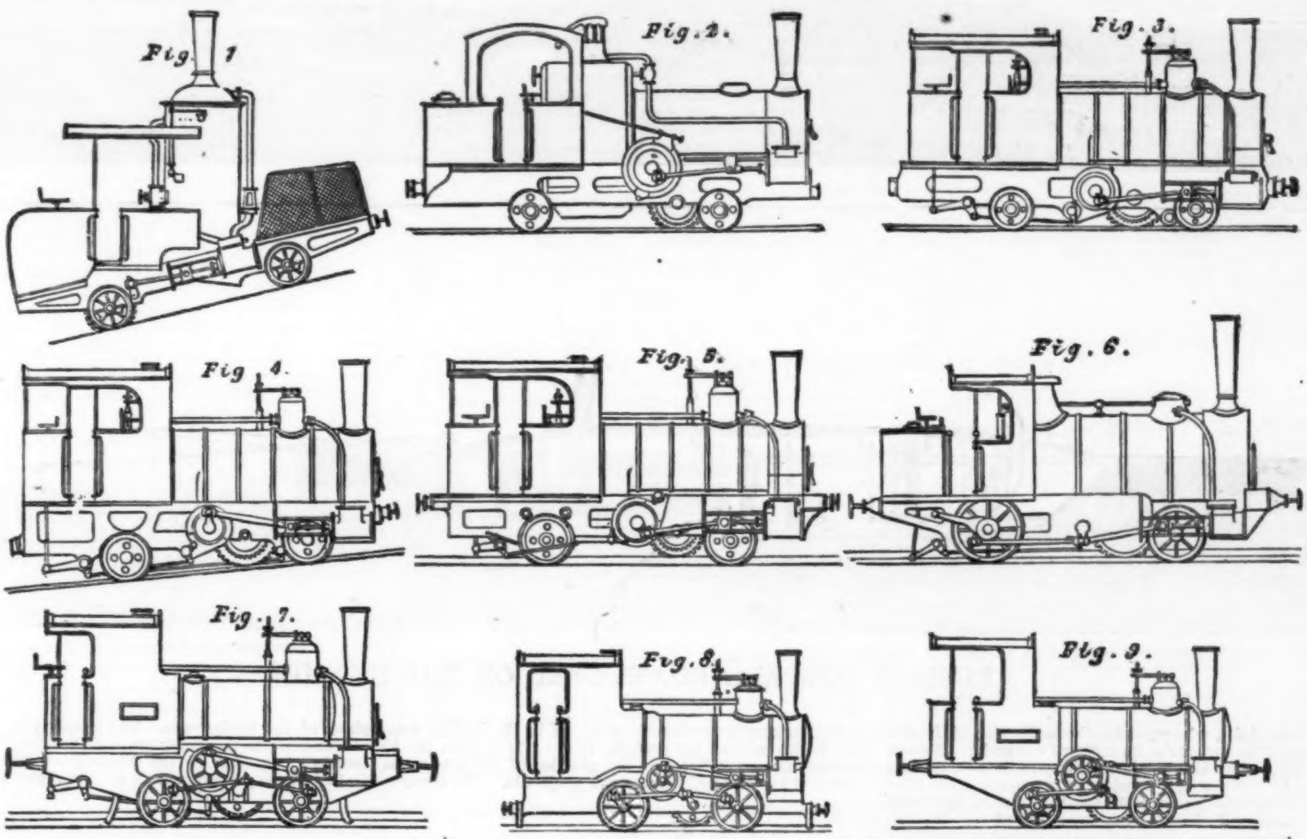
It being, however, found that the locomotives above named were not quite free from defects, and the Société Internationale des Chemins de Fer de Montagne, thinking it advisable to retain the manufacture in their own hands, they decided to start for themselves special workshops at Aarau, and from that time all the rack-rail engines have been built at these works under M. Riggenbach's superintendence. The engines thus built include those for the railway at Pesth; the Arth-Rigi, Fig. 4; the Rorschack-Heiden on the Lake Constance, Fig. 5; the Ostermundigen, near Berne, Figs. 6 and 7, for connecting large quarries to the line of the Central Swiss Railway; the line to the royal ironworks of Wasseralfingen, Wurtemberg, Fig. 8; and the line to the works of M. Caspar Honnegger, at Rüti, Fig. 9. This last-mentioned line unites M. Caspar Honnegger's factory to the Swiss Union Railway at Ruti station, and presents a gradient of 1 in 10, the gauge being 4 ft. 8½ in., so that the ordinary railway wagons can be brought into the factory. The weight of the several locomotives constructed for these railways varies according to the construction of the lines and the loads to be dealt with, from 10 tons to 30 tons, while the power they are capable of developing varies from 80 to 400 horse power. The smallest rack-rail locomotive yet made is that shown by Fig. 9, for the Rüti Railway, its weight being 10 tons, and it being capable of taking a load of 25 tons up the gradient of 1 in 10. On the other hand, the largest locomotives yet designed, and which will soon be at work, have been arranged for use on main lines, and weigh 30 tons, these engines being intended when working as ordinary locomotives to take a train of 120 tons up a gradient of 18 per 1,000, or 1 in 55·5, at a speed of from 9 to 12 miles per hour, while when working on the rack-rail they are to take a similar load at a speed of 6 miles per hour up a gradient of 1 in 20. For goods traffic it is proposed to employ two locomotives, one at the front and the other at the rear of the train, so that a load of 240 tons may be taken up. In these engines for main line traffic the arrangement is such that, when a steep gradient is being ascended by the aid of the rack-rail, the ordinary driving wheels become carrying wheels only, while, on the other hand, when the engine is being used as an ordinary locomotive, the rack-rail gear does not work.

It has been objected that snow would seriously interfere with the working of rack-rail railways, but experience seems to disprove this, it having been found on the Ostermundigen and Rorschack-Heiden lines, which are situated in the coldest parts of Switzerland, that snow does not form a greater obstacle than on ordinary railways. The first-mentioned of these lines has now been worked for seven years during winter as well as summer, while the latter has been in use two years, and notwithstanding the heavy snows of the winter just passed neither of them had to stop working.

Altogether the rack-rail system has many points in its favor, and we regard it as decidedly preferable in every respect to Mr. Fell's system of center rail with horizontal gripping wheels. That its employment will become considerably extended cannot be doubted, and we may mention that the Government of Baden has ordered the survey of a line on this system from Fribourg to Neustadt, and to Donaueschingen in the Black Forest, this line having gradients of from 50 to 60 per 1,000.

Hereafter we shall probably have more to say about the rack-rail system, but at present we may state in conclusion that there are at present 32 of M. Riggenbach's rack-rail locomotives at work, these being as follows:

On the Witznau-Rigi ten engines of the types shown by Fig. 1 on the previous page; on the Kahlenberg six engines of the type shown by Fig. 2; on the Schwabenberg (Pesth) four of the type shown by Fig. 3; on the Arth-Rigi, five of the type shown by Fig. 4; on the Rorschack-Heiden three of the type shown by Fig. 5; on the Ostermundigen two respectively of the types shown by Figs. 6 and 7; on the Wasseralfingen (Wurtemberg) one of the type shown by Fig. 8; and on the Rüti one of the pattern shown by Fig. 9.—*Engineering.*



PROGRESS OF RACK RAILWAYS.

THE HOOSAC TUNNEL.

THE tunnel is 26 feet wide, 22 feet high, four and three-quarter miles in length, through solid rock, the height of the mountain above it being 1,718 feet. The rock is granite, gneiss and mica schist. The portal of the tunnel at North Adams, Mass., is 766 feet above tide-water, the grade per mile from the portals to the central shaft is 26½ feet. The depth of the central shaft is 1,028 feet. A constant strong current of air flows upward through the great central shaft and keeps the tunnel perfectly ventilated.

THE New York Central and Hudson River Railroad Company have been experimenting for some time past to discover how long a locomotive can be run with due regard to economy, without repairs. It is found that locomotive No. 90 has run 70,000 miles in eleven months without going to a repair shop.

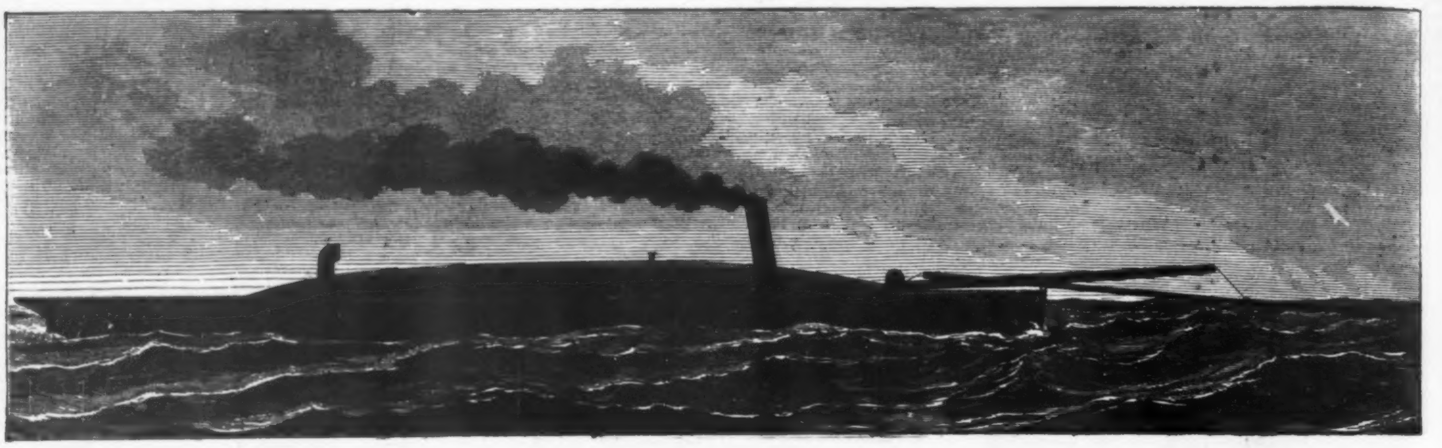
BROAD WHEEL TIRES.

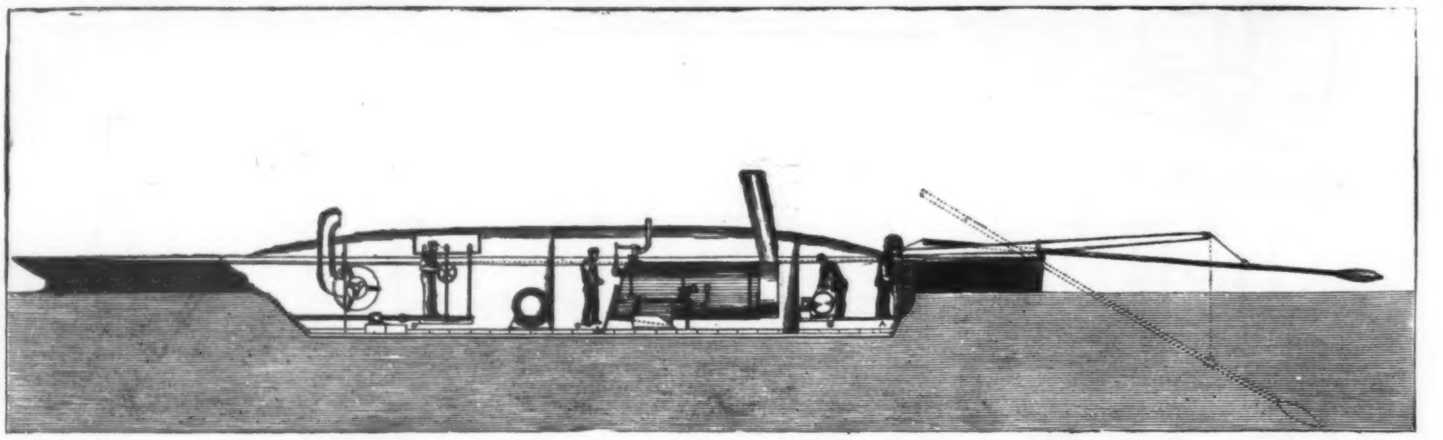
PARIS levies a tax which has indirectly preserved her asphalt pavements from destruction. The municipality levies a graduated tax on wheel tires, which is heavy on the narrow ones and almost nothing on the very broad. The latter are therefore almost exclusively used, and consequently no ruts are worn in the streets.

RUSSIAN TORPEDO BOATS.

IN our SUPPLEMENT, No. 79, we gave illustrations of fast torpedo boats and star torpedoes, as used in the British navy. We now give illustrations of smaller torpedo boats, now used by the Russians in the Danube. These boats are of steel, built by Messrs Yarrow & Co., at Poplar, Eng., for the Russian Government, and the interior of which is shown in a side section, among our illustrations.

The steersman will be seen in the forward end of the vessel. He has the entire movements of the boat under his control. He not only steers, but also regulates the speed of the engines. To protect his head from being struck by shot, he is provided with a kind of steel helmet, perforated with holes at the level of the line of vision, for him to look through. Close to him, in the same compartment, will be seen the torpedoist, who regulates the inclination of the pole which carries the torpedo at its forward extremity. He also fires the torpedo by means of electricity at the proper time. The torpedo itself simply consists of a copper case filled with a charge varying from 30 lbs. to 50 lbs. of dynamite, which is amply sufficient to sink any vessel afloat. The remaining two men seen on board are to attend to the boiler and machinery, all of them being protected by a rifle-proof steel shield or deck. This vessel is provided with one bow-pole only; but Messrs. Yarrow & Co. sometimes fit two poles, so as to insure a greater certainty of success. In working this class of boat the engines are reversed immediately before the torpedo comes in contact, so that the boat may recede after the explosion as quickly as possible out of harm's way; but for further security Messrs. Yarrow & Co. fit the steel girder, which will be seen projecting about 12 ft. from the bows of the boat. It is arranged to slide back under considerable pressure, thereby, in case of collision, gradually reducing the forward motion of the launch. The illustration shows the pole and torpedo as they are previous to being lowered into the water, which is done the very last thing, when within a few feet of the vessel to be blown up. The torpedo when lowered is 20 ft. from the boat and 10 ft. below the surface of the water. The boat's speed is 18 to 20 miles an hour, and it is capable of steaming 150 to 200 miles.



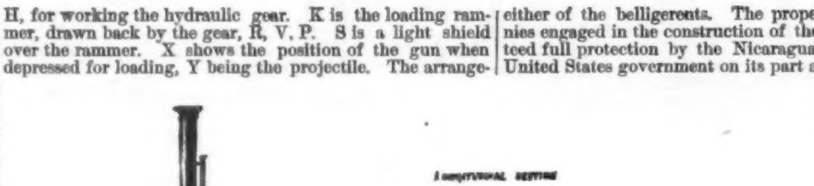


RUSSIAN TORPEDO BOATS USED ON THE DANUBE.

UNSINKABLE VESSEL OF WAR.—Those interested in the improvement of our present facilities for naval warfare have already heard of the unsinkable vessel of war proposed by Mr. W. M. Pollexfen, and that gentleman has now issued two letters with a view to render the principle thoroughly intelligible to those who are unacquainted with technical and mathematical tests. The principle of the invention can be very briefly explained; it consists in making the ship as near as practical a solid mass of timber, the only deviation from solidity being the construction of an impregnable compartment in the center for carrying the armament and machinery. The rectangular hold or space is of course arranged to be of suitable size, and Mr. Pollexfen even proposes to provide that the ship shall continue to float although the reversed compartment shall be completely filled with water, and still have buoyancy to spare. He points out that such a ship would be invincible, for though completely swamped, and the engine or other rooms flooded for a time, she could be managed with her sails and remain as formidable as any sailing vessel until her damage was repaired. But this is not all: the whole of the exposed portion of the hull being constructed of solid timbers, Mr. Pollexfen suggests with much show of plausibility that even a torpedo would not disable his ship, since the most it would in all probability do is to rend away, without detaching, one or two outside timbers, so that no less than a whole succession of torpedo attacks would render the vessel unseaworthy. He remarks that timber can be prepared so as to resist fire to a great extent, and if this preparation were found to interfere with the required weight of the timber in any particular instance, another method can be resorted to—that of rendering the exposed timbers fireproof. Mr. Pollexfen thinks it reasonable to expect the Admiralty to give the invention a practical trial, so as to prove the value of an invention which has met with such favor and received so many wishes of success.

THE ONE HUNDRED TON ARMSTRONG GUN.

THE engraving shows the 100 ton Armstrong gun, as mounted on its pontoon at Spezzia. A is one trunnion slide block. E the ram which takes up the recoil, working into the hydraulic press, D D, fixed at the rear of the bed girders, C C. F is a hydraulic press for elevating and depressing the gun. Z is the steam engine, supplied by the boiler, H, for working the hydraulic gear. K is the loading rammer, drawn back by the gear, R, V, P. S is a light shield over the rammer. X shows the position of the gun when depressed for loading, Y being the projectile. The arrangement has worked so well that its extended adoption is certain. Our drawing is from Stummer's *Ingenieur*. For performances of this gun, and for further illustrations, see SCIENTIFIC AMERICAN SUPPLEMENT, No. 62.



THE ITALIAN 100-TON GUN.

NICARAGUAN CANAL.

THE inter-ocean canal project is assuming more definite shape, inspiring the belief that at no remote day active work on it may be announced. To the action of the President, and his strong convictions of its being a commercial necessity, are we mainly indebted for the progress so far made. He has secured the concurrence of Great Britain, Germany, and Russia, but up to the latest advices Italy, France and Austria had not advised upon their course. Spain, though favoring the work, cannot contribute to its construction, owing to an exhausted exchequer. The footing upon which the project now rests can be better understood from the main features of treaty draft signed on the 2d ult. by our Government and Dr. Adams Cardenes on the part of Nicaragua. This treaty has been sent to the United States Senate for ratification; and a copy of it will be conveyed by Dr. Cardenes to his Government for ratification. The main features of the treaty are as follows: It provides for a ship canal from the Atlantic coast of Nicaragua, at or near Greytown, to the San Juan river. Thence by slack water navigation to Lake Nicaragua and across it to the Rio del Medio. The canal is then to be continued to the Pacific coast at or near Rio del Brito. The Government of Nicaragua on its part concedes the neutrality of a specified belt of territory, extending across the Isthmus, an equal neutrality for a distance of 100 miles out to sea at each end of the canal, while on the Gulf and on the Pacific the neutral territory is to extend along the coast 100 miles each way from ports and harbors that will be necessary for the free use of the canal. The ports of Greytown and Brito are to be free. In the event of a war between Nicaragua and any one of the powers which participate in the construction of the canal, all vessels and property of all those powers are to be exempt from capture, blockade, or any other embarrassment, on the neutral territory and waters connected with the canal, by either of the belligerents. The property of private companies engaged in the construction of the canal is also guaranteed full protection by the Nicaraguan Government. The United States government on its part agrees to use all influence in facilitating the construction of the work, and in conjunction with such other powers as may be engaged; when the canal is completed it agrees to provide full protection to all property from seizure or confiscation. It also guarantees the neutrality of the canal and all appurtenances, so that it may be forever open and free, and all capital invested in it may be secure. Those guarantees are to be withdrawn, if, at any time, the United States deem the management of the canal contrary to the regulations agreed upon in the treaty. All the leading maritime powers of the globe are to be invited to participate in and share the expense of the work, and to enter into treaty stipulations to the effect. If any difficulty should arise, the United States is to use its good offices to adjust them. The construction of the canal is to begin at the earliest practical moment, and the contractors are to have priority of claim upon all the property. When the work is completed, the canal is to be open to all citizens of the United States and of other nations, which participate in its construction, on equal terms.—*Chicago Jour. of Commerce.*

THE volcano Cotopaxi, in Ecuador, began belching smoke and ashes on the morning of June 26th, and in thirty hours thereafter, when the mail closed, it is estimated that six hundred miles of territory had been covered, and that in each square kilometer of space 313 kilogrammes of ashes had been deposited.

ROOTS' MINE VENTILATOR.*

By Mr. E. HAMER CARBUTT.

THE Roots' blower is a rotary air-compressing machine, as distinguished from a fan which throws the air off by centrifugal action. In principle it is analogous to a blowing cylinder, with the difference, that the air is expelled constantly in one direction and in four distinct volumes at each revolution of the blower; but with a blowing cylinder the direction of the current of air is altered at each end of the stroke.

For a long time previous to the introduction of Roots' blower into this country, it had been extensively used in America; blowers of a capacity of 100,000 cubic feet per minute had been constructed there, and one of this capacity was employed for working a pneumatic railway under Broadway, New York. The leading feature of Roots' blower consists of two duplicate rotary pistons, fixed upon separate shafts and working in a casing, which is provided with inlet and outlet openings either at the top and bottom, or at the sides, according to the position in which the machine is arranged. The rotary pistons in revolving are maintained in their proper relative positions by gearing on the shafts, and they revolve closely together, but not in actual contact with each other or with the casing.

FIG. 1.

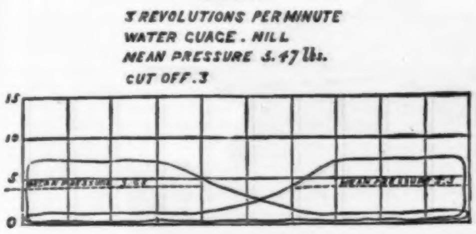


FIG. 2.

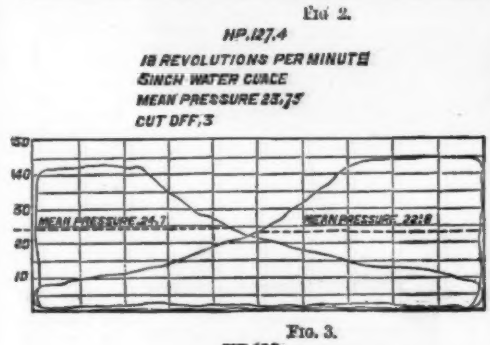
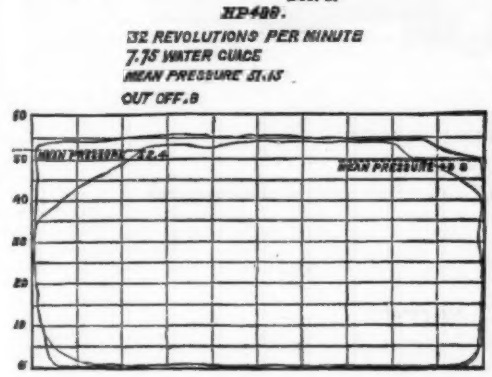


FIG. 3.



As a ventilator for mines the blower is shown in the engraving. This ventilator has been fixed at the Clinton Colliery, near Ferryhill, belonging to the South Durham Coal Company, and was started at the beginning of this year, it having been in constant work up to the present time. It consists of the two rotary pistons A A, which are each 25 ft. diameter and 13 ft. wide, and are built up upon steel shafts. Upon each of the shafts are keyed five cast iron disc plates C C, having flanges at their circumference which are all turned to exactly the same diameter. In each disc plate there are three wrought iron bars D fixed on each side of the center, and reaching to the outside of the rotary piston; planed recesses are provided in the disc plates to receive the bars, which are also secured to the disc plates by bolts turned to fit. The outer ends of the bars are widened, and mortised and slotted to the radius of the outer circle. Angle irons bent to the radius of the outer circle are riveted to the extremities of the bars, and are covered with ¼ in. sheet iron plate; the center circles are also covered with ¼ in. sheet iron plates on the turned flanges of the disc plates C C. The sides F F of the pistons are covered with wood, and the ends with sheet iron. These rotary pistons revolve in bearings fixed upon deep cast iron girders, which form the framework of the ventilator pit, and are connected together at each end of the ventilator by cross girders. The girders and the cast iron side plates above them are planed on their inside surfaces, and the stonework of the ventilator pit is dressed off level with the planed girders. The engines to drive the ventilator are a pair of 28 in. cylinders with 4 ft. stroke, and provided with adjustable cut-off valves. They are placed at right angles to the ventilator, and are connected to it with bevel wheels 9 ft. 2½ in. diameter, two bevel wheels being fixed upon the crank shaft, each gearing into a bevel wheel keyed upon the end of the ventilator shafts. The engine beds are carried along and fixed upon a stay girder, securely keyed and bolted to the main girder G. The main girders are fixed 13 ft. ½ in. apart, therefore the clearance between the rotary pistons of 13 ft. and the sides the ventilator pit is only ¼ in. on each side. At each end of the ventilator pit, and at the bottom on each side of the inlet from the upcast shaft, adjustable packing blocks of timber are fixed upon hinged iron frames, and can be adjusted with screws and nut; these blocks are set up quite close to the periphery of the rotary pistons within ¼ in. The clearance between the periphery of one of the rotary pistons and the center circle of the other is also the same, and thus in any part of the ventilator the clearance for loss by returning of the air is not more than ¼ in.; this will account for the measured quantities of air in Table II., corresponding so closely with the calculated capacity or displacement, which is 5,800 cubic feet per revolution. Between the packing blocks I I the ventilator pit is dug out and lined with cement; but there is considerable space between the layer of cement and the outside circle of the rotary pistons, and dependence is placed only upon the packing blocks to maintain the tightness of the pistons with the ends of the ventilator pit.

The rotary pistons are equally balanced, and also the parts of the engine; and the friction diagram, taken during experiment No. 1, Table III., shows that 3·10 indicated horse power maintained the ventilator and engine running at a constant speed of three revolutions per minute; this shows that the balancing has had attention, and that not much power is lost in the friction of the moving parts. Clinton Colliery is a new pit raising 800 tons of coal per day, and the present requirements in the way of ventilation are amply met by running the ventilator at 15 revolutions per minute, giving a calculated displacement of 87,000 cubic feet of air per minute. At this speed better results would be obtained by using only one cylinder, and letting the other engine stand, as will be done in the case of repairs; the two engines are only intended to be used when the ventilator is working up to its full maximum quantity of 200,000 cubic feet of air per minute. The arrangement of the engine house and ventilator building is shown in the engraving; the discharged air escapes through perforated openings in the roof, and, owing to the very large area of outlet from the ventilator—the top of the ventilator casing being left entirely open—the air that is being exhausted from the pit must necessarily be delivered into the atmosphere at a lower velocity than is usual with other ventilating machines.

The tabulated statements appended, Tables I., II., and III., contain the results of experiments made at two trials of this ventilator. In the anemometer measurements, Biram's anemometer was employed, and the readings in Table I. are corrected by means of a table supplied with the instruments, which was tested for the purpose of these trials. In some of the experiments the anemometer and water gauge measurements were taken simultaneously with indicator diagrams, from both engine cylinders; some of the indicator diagrams are shown in Figs. 1, 2, and 3. The areas and position of upcast shaft and tunnel are shown in engraving; the sectional area of the tunnel is only 112 square feet at the point where the anemometer measurements were taken, which is much too small.

The useful effect obtained with this ventilator is shown in Table III.; and for the purpose of comparison, the following particulars are reproduced from the paper on mechanical ventilators for mines by Mr. Daniel at the meeting of the Institution, Nov., 1875, the lowest as well as the highest results being given in the case of the Roots' and the Cooke's ventilators, and the highest alone in the case of the others.

This comparison shows that the range of Roots' blower, when employed as an exhauster, is in advance of any of the previous mechanical ventilators; and in the writer's opinion this would be a decided advantage in the case of an explosion. When the air doors become disarranged, the ventilation of the mine is interfered with at the moment when it would be of the greatest service, and this owing to the limited power of fan ventilators, which can only be depended upon up to about 3 in. water gauge; but in a case of emergency, with a Roots' ventilator similar to the one described, the machine could be instantly driven at its maximum power, and would speedily clear the workings of the choke-damp, fire-damp, or after-damp. Since explosions cannot always be prevented, it is of importance that the deadly gases should be drawn out in the shortest possible space of time, and replaced with pure air; and from present experience this ventilator appears to be well fitted to suit these requirements.

		Ventilator. Diam.	Ventilator. Width.	Air per minute.	Water gauge.	Revolutions per minute.	Useful effect.
		ft.	ft.	cub. feet.	in.		Pr cent.
Roots ..	Chilton	25 ×	13	74 928	4·00	13	76·85
				101,696	5·00	18	64·19
				67,312	2·75	12	56·30
				118,272	4·12	21	51·40
Cooke ..	Lofthouse.. ..	22 ×	11½	101,308	1·12	26	64·00
				96,757	1·00	28	59·16
	Upleatham ..	22 ×	11½	88,900	3·25	27	61·18
				120,816	1·56	29	53·50
Waddle ..	Aberaman.. ..	36 ×	1½	120,104	1·60	44	47·10
Rammell.	Cannock Chase .	32 ×	½	45,280	2·10	55	41·02
Leeds Fan	Morley Main ..	40 ×	10	141,584	1·80	44	37·92
Guibal ..	Farnley Wood..	21 ×	7	38,900	0·90	58	50·41
	Liverton	36 ×	12	171,688	2·55	51	48·85
	Hilda	50 ×	12	116,792	2·63	36	45·81
	Skelton	30 ×	10	52,544	0·50	28	45·64
	Craggs Hall ..	30 ×	10	56,072	1·40	43	40·66

During the discussion of this paper reference was made to the Baker blower, now pretty well known in this country. It may be described as consisting mainly of a casing, inclosing three horizonal drums, the upper one carrying two blades, the same length as the drum, and the ends of which run close to the ends of the casing. The lower drums have a portion of their circumference slotted out to admit the blades, and run at double the speed of the drum. These drums thus act as valves, admitting the air first, but preventing any appreciable loss on the delivery side of the uppermost blade. The drums are connected by strong gearing; the shafts run in long bearings, and the whole of the parts are of iron. A steady blast of about 1½ lb. per square inch is easily maintained in an ordinary cupola, with less power, it is claimed, than would drive a fan giving less than 1 lb. pressure. Some recent experiments with a cupola 37 in. inside the lining, and a blower with 113 in. delivery pipe, showed that with 7·5-horse power 8·102 lb. of iron were melted per pound of coal used, and 152 lb. of iron melted per minute. These blowers are made by the Saville Street Foundry Company, Sheffield.

RECENTLY, says the *Milledgeville* (Ga.) *Reporter*, a little colored girl, nine years of age, daughter of Samuel Phelps, was passing over the railroad bridge which spans Fishing creek near the depot, with a large parasol stretched over her head, when the blast struck her, and in a moment she was swept off the bridge and was falling to the earth sixty feet below. A lady who saw the affair from a short distance off, says that she went down hanging to the umbrella, which was stretched over her head like a parachute. The handle broke just before she reached the ground. She was but comparatively little injured; the parasol acted as a parachute.

TABLE I.—*Roots' Mine Ventilator at Chilton Colliery, Ferryhill. Velocities of Air in Different Portions of Area of Tunnel.*

No. of experiment	3	4	5	7	8	10	12	16
Revolutions per minute of ventilator	10·5	12	13	17	18	21	23	37
Mean velocity of air	Feet p. min. 581	Feet p. min. 601	Feet p. min. 669	Feet p. min. 882	Feet p. min. 908	Feet p. min. 1056	Feet p. min. 1155	Feet p. min. 2185

TABLE II.—*Roots' Mine Ventilator at Chilton Colliery, Ferryhill. Measured and Theoretical Deliveries of Air at Different Velocities.*

No. of experiment		3	4	5	7	8	10	12	16
Date of experiment..	1877.	Mar. 17.	Mar. 17.	Mar. 17.	Mar. 17.	Feb. 3.	Feb. 3.	Mar. 17.	Feb. 3
Revolutions of ventilator .. .. R	per min.	10·5	12	13	17	18	21	23	37
Velocity of air in tunnel (Table I. V	feet per min.	581	601	669	882	908	1056	1155	2185
Delivery of air { Theoretical* R × 5800 = T	cub. ft. p. min.	60,900	69,600	75 400	98,6 0	104,400	121,800	133,400	214,600
Delivery of air { Measured† V × 112 = M	Do.	59,472	67,312	74,928	98,784	101,696	118,272	129,360	244,720
Ratio .. .. $\frac{M}{T}$ × 100 ..	per cent.	97·65	96·71	99·37	100·18	97·41	97·10	96·97	114·04
Leakage	per cent.	2·35	3·29	0·63	—	2·59	2·90	3·03	—

* The theoretical delivery is the capacity of the ventilator (5800 cubic feet) × revolutions per minute.
† The measured delivery is the velocity in the tunnel × 112 square feet sectional area of tunnel.
In Nos. 4, 5, 8, 10 the air measurements in Table I. were taken simultaneously with those of indicated horse-power given in Table III.
The experiments Nos. 3, 7, 12, 16 are not carried out in Table III., the whole of the data not being obtained in those cases.

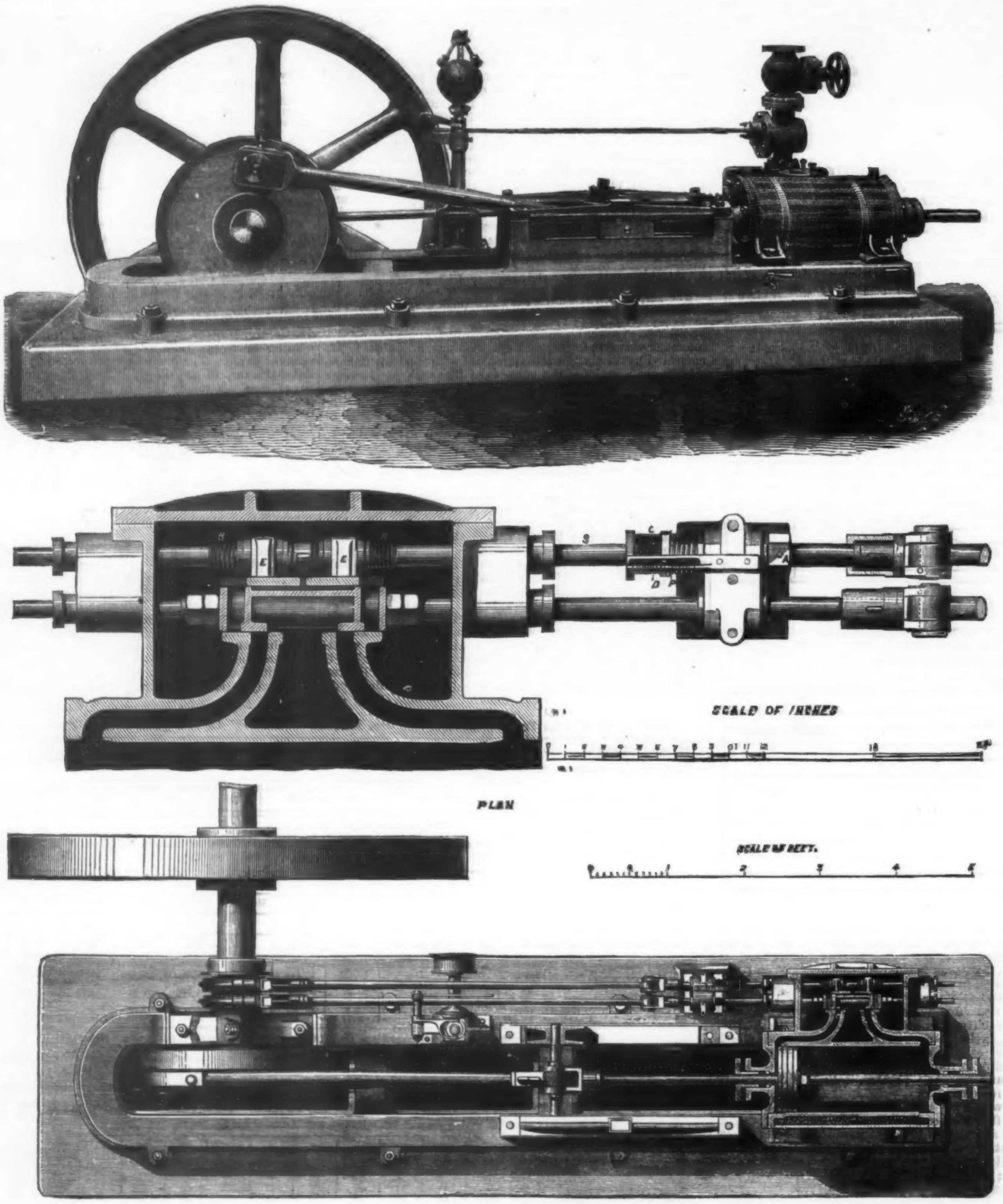
TABLE III.—*Roots' Mine Ventilator at Chilton Colliery, Ferryhill. Useful Effect of Ventilator and Engine.*
Engine with two cylinders, 28in. diameter and 4ft. stroke.

No of experiment		1	2	4	5	6	8	9	10	11	13	14	15
Date of experiment	1877.	Mar. 16.	Mar. 16.	Mar. 17.	Mar. 17.	Feb. 3.	Feb. 3.	Feb. 3.	Feb. 3.	Feb. 3.	Mar. 17.	Mar. 17.	Mar. 17.
Revolutions of ventilator and engine .. .. R	per min.	3	8	12	13	14	18	20	21	22	28	30	32
Steam pressure in pipes ..	lb. per in.	33	35	37	40	45	45	45	40	45	45	52	60
Point of cut-off in engine ..	per cent.	30	30	30	30	30	30	40	30	40	80	80	80
Delivery of air:													
Theoretical.. R × 5800 = T	cub. ft. p. min.	—	46,400	69,600	75,400	81,200	104,400	116,000	121,800	127,600	162,400	174,000	185,000
Measured (Table II.) .. M	Do.	—	—	67,312	74,928	—	101,696	—	118,272	—	—	—	—
Water gauge .. .. W	inches.	0·00	1·25	2·75	4·00	4·00	5·00	6·50	4·12	5·87	6·00	7·00	7·75
Mean effective steam pressure:													
Right cylinder	lb. per in.	3·47	6·65	14·47	—	17·65	22·80	29·80	23·95	30·65	—	46·40	51·15
Left cylinder	Do.	—	—	—	15·85	17·25	23·75	29·30	23·70	31·25	39·85	—	—
I.H.P. from diagrams:													
Right cylinder	H.-P.	—	—	—	—	73·68	122·30	177·70	149·90	203·00	—	—	—
Left cylinder	Do.	—	—	—	—	72·01	127·40	174·70	148·40	205·09	—	—	—
Mean	I.H.P.	3·10	15·50	51·79	61·44	72·84	124·85	176·20	149·15	204·00	332·70	415·00	488·00
Effective H.-P.:													
Theoretcl $\frac{T \times W \times 5{\cdot}2}{33{,}000}$ = Et	H.-P.	Frictional diagrams.	9·14	30·16	47·52	51·18	82·25	118·81	79·17	118·12	152·54	191·98	226·86
Measured $\frac{M \times W \times 5{\cdot}2}{33{,}000}$ = Em	H.-P.		—	29·16	47·22	—	80·12	—	76·88	—	—	—	—
Useful effect. Ventilator and engine:													
Theoretical $\frac{Et}{I}$ × 100 ..	per cent.		58·96	58·22	77·34	70·26	65·90	67·42	53·09	57·90	46·14	46·24	46·24
Measured $\frac{Em}{I}$ × 100 ..	per cent.		—	56·29	76·85	—	64·19	—	51·40	—	—	—	—

* Abstract of paper read before the Institution of Mechanical Engineers, London.

TEN HORSE POWER ENGINE.

OUR illustrations show the details of a new ten horse power engine, exhibited at the recent show of the Bath and West of England Society at Bath. It is the design and make of Messrs. J. Watts & Co. It is especially designed to work at high speeds, and for driving machinery liable to sudden and extreme variations of load. The principal dimensions are as follows: Cylinder, 10 in. diameter; length of stroke, 20 in.; steam ports, ⅞ in. wide by 7 in. long; exhaust port, 2 in. wide by 7 in. long; slide blocks of cast iron, 9 in. long by 3 in. wide. The bottom slide bars have a well at each end, and the two sides are carried up ⅜ in. above the level of the bar to retain the oil. The connecting rod is 5 ft. in length between centers, by the collar head as shown. By turning the hexagonal nut A, the valve spindle S is turned, and with it the two screws B B, carrying the cut-off valves E E, the amount of their movement being indicated by the pointer P, working on the screw C, and indicating on the scale D the range of expansion. The normal speed of the engine is 120 revolutions per minute. The governor is Widmark's patent, with a split ball, an arrangement now largely used and favorably spoken of as sensitive in its action. It is coupled direct to an equilibrium throttle valve fixed on the steam chest. It will be seen from the illustrations that the engine is well designed, the working parts are large, and, we may add, the workmanship is excellent. The bottom of the bed plate is planed, in order to increase the firmness of its bearing on the foundation, and to facilitate fixing.—*The Engineer.*



TEN HORSE-POWER HORIZONTAL ENGINE. BY WATTS & CO.

the large end is solid, the back half of the brass being set up by a wedge block, held in position by two screws. The crank shaft is of wrought iron, with a journal 4½ in. diameter by 6 in. length. The crank pin is of steel, 3 in. diameter by 3½ in. long. The crank disc is of cast iron, balance weighted, and the fly-wheel, 6 ft. in diameter, weighs 1 ton. It is cast with a split boss, hooped with wrought iron rings, a practice now largely adopted, as effectively preventing most of the internal strain to which wheels cast with whole bosses are subject. Almost all strain would be removed by casting such wheels with bosses split in three places. The cylinder is fitted with expansion valves working at the back of the main slide, these expansion valves being adjusted, as shown by the enlarged detail, by means of right and left hand screws, the two cut-off valves being carried by flanged nuts on the latter. The same figure illustrates the arrangement for altering the range of expansion while the engine is running. It will be seen that the expansion valve spindle is capable of rotation, it being held to the eccentric rod joint

THE TIDES.

By Professor ELIAS SCHNEIDER.

THERE has always been a difficulty in the minds of teachers, as well as in the minds of learners, to comprehend the theory of the tides as presented in our text-books. This theory fails to give a satisfactory account of the cause of the tides on the side of the earth most remote from the sun and moon. According to this theory, at the part of the earth's surface which is turned away from the moon or from the sun, a less amount of attraction is felt by her waters than anywhere else on her surface; and the whole earth is therefore, in effect, drawn away from the waters on the far side of her, and thus, the water being left behind, a tide is produced on this side, as well as on the side at which the force of gravity acts directly. That so great an absurdity could have been accepted so long by our writers of text-books, is truly marvelous. It is indeed, so contrary to all known facts and laws of physics that, if no other influence were felt by the waters at the far side of the earth than attraction, there would be just the opposite effect produced to that alleged by this absurd hypothesis. This can be demonstrated by actual experiment, and as conclusively as any other fact coming within the reach of experimental philosophy. It has been proved experimentally that all bodies on the surface of the earth at midnight are heavier than at any other hour of the twenty-four; and that when new moon occurs at midnight, this increase of weight or gravity felt by matter on this part of the surface of the earth is still greater. Now, if this theory were correct, attraction would produce just the opposite effect; that is, matter would weigh less at midnight than at other hours of the twenty-four. On the side of the earth facing the sun and moon, the weight of bodies is diminished, as it should be, according to the theory which I propose to establish in this article.

The truth of this fact is very easily accounted for. Suppose the earth were placed in such a position, in space, that she could not feel *any* of the sun's attraction, nor that of any *other* body. Then gravity would be equal on all parts of the earth's surface, on the supposition of its being a perfect sphere and at rest. But now bring her within the attractive influence of the sun. Then all particles of matter on the earth's surface most remote from the sun would feel the force of gravity of both the sun and the earth; and these two forces would act in the same direction and in the same straight line, directed through the center of the earth to the center of the sun. On the side facing the sun, these two forces would act in the same straight line, but in opposite directions. Hence a decrease of weight on one side and an increase thereof on the opposite side of the earth. The same result follows between the earth and moon under a similar supposition. It is therefore not true that the least amount of at-

traction is felt by the waters of the earth at that part of her surface most remote from the sun or from the moon. It is indeed true that the sun and moon *have* less power of attraction on the particles of matter facing them. But, as attraction diminishes as the square of the distance increases, this attractive force of these two bodies on any part of the earth's surface is not near so great as that of the earth herself on such part of her surface. Therefore, as these remote particles feel the attraction of sun and moon *plus* the attraction of the earth herself, they are drawn with greater force toward the center of the earth than any other particles. Consequently, it cannot be true that the whole earth is drawn away from the waters, and that any tide is produced by the waters being left behind.

How then, can we account for tides occurring on opposite sides of the earth at the same time? Let us see. In the first place, suppose the earth to occupy some place in space, and to be in a state of perfect rest. Then suppose the sun to come into position, and the earth to start on her journey of 68,000 miles an hour in her orbit around the sun; and suppose, too, that the earth rotates only once on her axis during one revolution around the sun. Then will the same side of her surface face the sun in every part of her orbit. Consequently, there will be a solar tide perpetually at a part of her surface, produced by centrifugal force, and at that part farthest from the sun. Night and solar tide will reign with unceasing steadiness at that one place; but there will be no motion of these piled-up waters. There they will stay, in a steady equilibrium, by the unceasing effect of centrifugal force, in the same manner as can be illustrated by swinging a hollow globe, partially filled with water, around the hand by means of a cord, or by swinging a bucket filled with the same liquid, and having for its bottom a piece of india-rubber, which bottom will bulge out when the bucket is swung around a center, in the same manner as do the waters of the far side of the earth when she swings or sweeps around the central sun with a velocity of 68,000 miles an hour.

But there are always two solar tides occurring on opposite sides of the earth. The above explanation accounts only for the solar tide on the side of the earth farthest from the sun. How must we account for the fact that there is also one on her side facing the sun and occurring near noon? It is a well known law of planetary motion that centrifugal and centripetal forces are precisely equal. By virtue of the first the earth seeks to fly from her center of motion; by virtue of the second she has a tendency to fall into the central luminary; and everything on her surface is operated on in like manner. The particles of her water, moving very easily among one another, are therefore drawn readily away from her solid portions in opposite directions. On the one side the bulging out is caused by centrifugal, on the other by centripetal force. But, as these two forces are nearly equal in all parts of the earth's orbit, the tide waves on opposite sides of her surface must also be nearly equal. The centrifugal force is produced by the revolution of the earth around the sun; the centripetal force is caused by the force of gravity lodged in the great central orb.

It must not be understood, however, that the earth in her orbital motion feels the effect of these two forces at her surface only. Every *particle* of the matter composing the earth feels both a centrifugal and a centripetal force while this planet moves around the central orb, and these two forces are precisely equal only at the *center* of the earth. But the matter of her surface most remote from the sun feels a centrifugal force that is in excess of the centripetal force felt at this same point; and the matter of her surface facing the sun, being nearest to it, feels a centripetal force that is in excess of the centrifugal force felt at the same point. But these two excesses are equal; hence there are equal solar tides at these points, while at the earth's center there is an exact balancing of the two forces.

Suppose the matter of the earth were all condensed into the volume of a cubic inch, and that this small volume were placed at the earth's present center; then suppose it received an impulse carrying it forward with a velocity equal to that which moves the center of the earth, and that it were influenced by the sun, according to the law of gravity. This small volume, though equal in mass to the entire mass of the earth, would then move in the same curve in which the center of the earth moves, and with the same velocity. But suppose this solid inch of matter were to be placed 4,000 miles farther from the sun, namely, at that point in space where the earth's surface is most remote from the sun. This solid inch, or whole mass of the earth, would then move in a longer curve than it would when at her present center, as under the first supposition. But completing, nevertheless, in this longer curve, one revolution in the same time in which one revolution is completed in the shorter curve, at the earth's center, the centrifugal force would be much increased; and, the centripetal force being also diminished in the same ratio, this cubic inch of matter would either abandon the sun's companionship entirely or make a *new* orbit of motion. In like manner are the waters of the earth operated on by centrifugal force at this point of the earth's surface. They have a tendency to fly off in a line tangent to the earth's orbit.

Now, suppose again that this condensed matter of the earth were placed at that point in space where the earth's surface is nearest the sun, namely, 4,000 miles nearer the sun than the center of the earth is: then the whole mass of the earth's matter would move in a *shorter* curve than when placed at the center, but, completing one revolution in no shorter period, the centrifugal force would be diminished; and, being also nearer to the sun, the centripetal force would be much increased by the central power of attraction. Therefore, this body of matter would, under this supposition, also leave its orbit, but it would be drawn *toward* the sun, and probably plunge into it. In the one case, the centrifugal being greater than the centripetal force, the body would fly *from* its center of controlling power; in the other case, the centripetal being equally superior to the centrifugal force, the body would also be drawn out of its orbit, but dragged *to* the center of controlling power. These suppositions are made to show, by way of illustration, the excessive force of each kind over its opposite, at opposite sides of the earth. And these equally excessive forces, acting in such opposite directions, cause the opposite solar tides. The particles of water, moving easily among one another, are readily driven in opposite directions by these opposite forces. If the earth were *entirely* solid, then there could be no such bulging out of any of its matter, and therefore no tides.

A few words here in regard to the law of gravitation are in place. Every body of matter attracts every other body of matter, and with a force equal to the *amount* of matter each body contains; and this force diminishes as the square of the distance increases. Two bodies of equal mass approach each other equally; but, if one body contains four times as much matter as another, the smaller approaches the larger with a velocity four times as great as the larger does the smaller. Suppose two such bodies, being separated at a distance of 100,000 miles, attract each other with a certain known force: if this distance be increased to 200,000 miles, the force of attraction between these two bodies will be only one-fourth as great. In like manner the earth, at the point farthest from the sun, feels a *smaller* degree of attraction than the matter at the center. And, as the centrifugal force is also *greater* at this point than at the center, there is here an excess of centrifugal over centripetal force, and sufficient, as can be ascertained by exact mathematical calculation, to produce a solar tide. And at that part of the earth's surface which is nearest the sun, or facing it, there is, according to the same law of gravity, an excess of centripetal over centrifugal force. Hence we have also a solar tide at this part of the surface of the earth.

I give one more illustration. Suppose the earth, at *E*, (Fig. 1), is moving in a straight line toward *E*, and with a velocity of 68,000 miles an hour; and suppose when she reaches *E'* she comes under the attractive influence of the sun. She will then be deflected from her rectilineal course and move in a curvilineal orbit around the sun. That part of her surface turned away from the sun will be 8,000 miles farther from the attractive influence of the central orb than that part of her surface facing the sun. Hence this remote part will have a greater tendency to continue moving on in a straight line than any other part; and this tendency will show itself in the motion of its waters, by producing a tide. The waters will have a tendency to move in a line tangent to the orbit of the earth. The part of the earth's surface nearest the sun, being acted upon more powerfully by the gravitating influence of this central force than the remote part, will show a less tendency to move on in a line tangent to the earth's orbit. Hence there will be another tide produced by gravity directly.

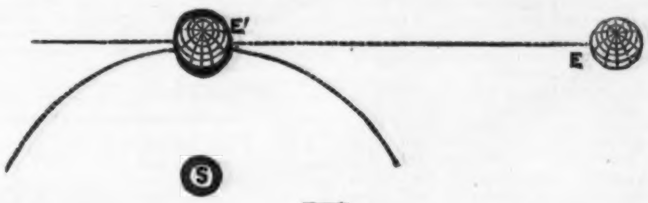


FIG. 1.

I have thus far spoken only of the solar tides. It will be necessary to say something of lunar tides, or what influence the moon has on the phenomena of the tides.

It is a well known fact that there is a point between the earth and her moon called their center of gravity. The distance between the centers of these two bodies is about 240,000 miles. A rough calculation brings the center of gravity of these bodies about 2,687 miles from the center of the earth, and 237,313 miles from the center of the moon. This point describes the curve of an ellipse around the sun; and the earth and moon revolve *around* this point, while they both sweep through space in their majestic journey around the sun. It is therefore evident that the earth, in her ceaseless motions, is influenced by three different centrifugal forces. The one is produced by rotation on her axis; the other by her revolution around the sun; and the third by her revolution around the center of gravity between herself and the moon.

Let us suppose that the earth and moon have no other motion in space than that of revolving around their common center of gravity, and that the same side of the earth is always facing the moon. The earth will then feel a centrifugal force on her side farthest from the moon, and equal to the centripetal force felt on her side facing the moon. These two equal forces, acting in opposite directions, will cause tide-waves on opposite sides of the earth; and they will be produced in the same manner as the opposite ones, spoken of already, are produced by centrifugal and centripetal forces felt by the earth in her orbital motion around the sun.

Let us now place the earth and moon in their proper position with respect to the sun; and let us suppose the moon to be in conjunction with the sun, as at *A*, Fig. 2. It is then new moon, and the moon's center is 237,313 miles *within* and the earth's center 2,687 miles *outside* the elliptic orb described by their center of gravity. At this point of her path the earth feels, therefore, the greatest amount of centrifugal force on the side of her surface farthest from the sun. This large amount of centrifugal force is produced by axial rotation, by revolution around the sun, and by revolution around the center of gravity already named. The direction of these three forces is in the same line. The motion of this part of her surface, which is in this line of direction, is therefore the most rapid; consequently, the centrifugal force felt here is also the greatest. *Therefore*, we have one of the highest tides when the moon is in conjunction with the sun; and, since centripetal is always equal to centrifugal force, the side of the earth facing the sun and moon at this point of her orbit must have an equally high tide at this time. The centripetal force here is produced by the gravity of both sun and moon acting jointly.

Let us now suppose the moon to be in quadrature, as at *B*. Then the two centrifugal forces, the one produced by revolution around the sun, the other by revolution around the center of gravity of these two bodies, do not act in the same line of direction, but at right angles with each other. The phenomena of solar and lunar tides are then about 90° apart; the solar being the smaller and the lunar the larger. Here the centers of both the earth and moon are *in* the path described by their center of gravity.

In the last place, let us suppose the moon and sun to be in opposition, as at *C*. Then, according to my theory, the earth feels, on her side farthest from the sun, an influence which diminishes the centrifugal force produced by her orbital revolution. For at this point the earth's center is *within* and the moon's center is *without* the elliptic path described by their center of gravity. Hence the revolution of the earth around this center of gravity is contrary to her general motion around the sun. But what is thus lost in centrifugal force on her side turned away from the sun is more than made up by the gravity exerted directly on her by the moon. And, on the side of the earth facing the sun, she feels a centrifugal force produced by revolution around the center of gravity of herself and the moon, and also a centripetal force produced by the gravitating influence of the sun. Hence there must be high tide also when sun and moon are in opposition.

It is a known fact the solar are less than the lunar tides. How must we account for this fact? The sun is a body so large that the mass of the moon is not much more than a grain of sand in comparison with it. But it must also be remembered that gravity diminishes as the square of the distance increases; and as the moon is very near the earth, and the sun a great way off, the lunar influence is much more strongly felt in the phenomena of tides than the solar influence.

The amount of centrifugal force felt by a body moving in space around a center depends, not only on the velocity with which it moves, but also upon the *size* of the curve in which it moves. If the circumference of the curve is very large, it differs not much from a straight line. If a body moves in space in the direction of a straight line, it feels no centrifugal force at all. If it is deflected from the direction of this straight line, only a very little, the circumference of the curve will be very long, and the centrifugal force will be small. But, if it is very much deflected, the curve becomes very small, and the body, turning around very "short corners," has a strong tendency to fly "off the track." In other words, in a short curve the centrifugal force is very great.

Now, let us make an examination of the orbital curve of the earth made in its motion around the sun. The length of the circumference of this curve is, in round numbers, about 570,000,000 miles. A straight line, 10,000 miles in length, tangent to this curve at one end, is only about .526 of a mile distant from the circumference at its other end. Therefore, the earth, moving in its orbital curve, feels rather a small amount of centrifugal force. But, in her motion around the center of gravity between herself and the moon, she turns very "short corners," and hence under this influence she experiences a greater amount of centrifugal force than in her motion around the sun. For this reason, *also*, the lunar are greater than the solar tides.

If the earth had only one rotation in one revolution around the sun, there would be, as already stated, one solar tide by virtue of centrifugal force occurring at midnight, and another by virtue of centripetal force occurring at noon. That is, perpetual night and high tide would occur at one

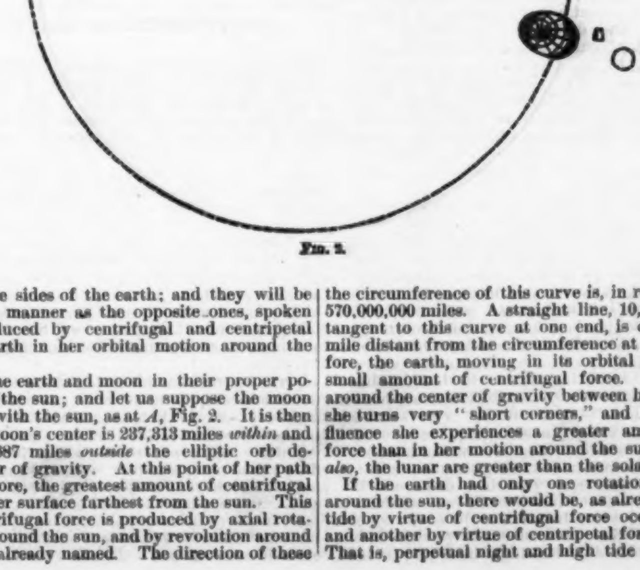


FIG. 2.

side, and perpetual day and high tide at precisely the opposite side of the earth. But now let us suppose the earth rotates on her axis once every twenty-four hours, and from west to east, as she actually does rotate: then there will be motion of the waters; but this motion will be only *apparent* motion, and from east to west. The *real* motion will be that of the solid portion of the earth that moves from west to east, and underneath these waves, though these waves do also acquire, by means of friction, a *part* of this motion; yet the centrifugal and centripetal forces are so much superior as to master the effect of this friction. This frictional force carries also these tide-waves so far eastward that they occur always several hours east of the meridian; that is, several hours *after* noon, and several hours after midnight.

It is a known fact that the waters of the tides rush up the rivers and small bays on the east coasts of all countries with great violence, but not up those on the west coasts. The reason of this is very evident. The west coasts turn away from the tide waves; while the east coasts, moving with a velocity of nearly 1,000 miles an hour, in rotation, within all parts of the tropics, dash violently eastward against these waves. For this reason the waters, by resistance or inertia, *appear* to be driven violently westward up the streams and bays, while it is the mouths of these channels ploughing with violence into the tide-waves themselves.

It has been stated in this article that gravity is greater at that part of the earth's surface turned away from sun and moon than anywhere else. It may be asked, "How then can centrifugal force drive out the water above the usual level when its weight is increased?" This force acts in a line tangent to the earth's orbit, which tangent line, being perpendicular to the radius vector at perihelion and aphelion, and at all other points in the earth's orbit very nearly so, may be said to be at right angles with a line extending from this point of tangency through the center of the earth to the center of the sun. Therefore, the attractive power of the sun acts on matter, at the part of the earth most remote from it, in the direction of the radius vector; and centrifugal force acts on this same matter in a direction at right angles with the radius vector. Now, as was first demonstrated by Galileo, the motion of a body, produced by one force, is not destroyed by another force acting on this same body at right angles with it. The result of these two combined forces is only a change in the *direction* of motion. But, as has already been shown, centrifugal is always in excess of centripetal force at the place of the earth now under consideration. Hence this tide-wave at this side.

I conclude by saying that the great motions of the waters of the mighty deep are most assuredly the grandest ocular demonstrations of the rotation of the earth upon her axis, and of her revolution around the sun, that can be witnessed by the eyes of man.—*Popular Science Monthly.*

FINE WATER DROPS.

At a recent meeting of the Austrian Society of Meteorology M. Obermayer read a paper in which he gave a summary of the facts ascertained regarding the nature of mist particles. The following is an abstract of the paper:—The question is not yet finally determined whether mist particles are fesicles or fine drops, but opinion is now pretty general in favor of the latter view. The hypothesis of mist vesicles involves the considerable difficulty of explaining their origin, and the supposition (which was accepted by Leibnitz and Halley) was formed principally to account for the floating of mist particles in the atmosphere. In more recent times it has, of course, been perceived that water drops also may float in the atmosphere, since particles of dust and smoke can do so.

The question as to the nature of mist particles would have been straightway decided if direct observation with the microscope had led to definite results, but all these experiments were quite unsuccessful. The floating of small bodies that are specifically heavier than air was explained by Stokes in 1856, by the internal friction of the air. The formula developed by Stokes from hydrodynamic equations of motion with reference to the internal friction of liquids give, for mist particles of 0·002cm. and 0·0002cm. diameter, the values 1·2cm. and 0·012cm. for the velocity in a second. The diameters of mist particles have actually been measured. Kamtz found them between 0·0011cm. and 0·0054cm. A diameter of 0·0002 is still very considerable, and lies quite within the bounds of possibility. The probable diameter of a water molecule is about 0·00000005cm. The wave-lengths of Fraunhofer's lines A and H are 0·000076cm. and 0·000039cm.

The hypothesis of vesicular form has also been maintained in opposition to that of water drops, on optical grounds. First of all is the circumstance that rain drops give a rainbow, which, it is known, is not produced by cloud particles. For explanation, also, of the color of the sky, and the morning and evening glow, Clausius (especially) has resorted to the hypothesis of mist vesicles. The reckoning of Clausius rests on the supposition that the density of such vesicles cannot differ materially from that of the atmosphere; but Budde has pointed out that, in consequence of capillary action, the air inclosed in such vesicles must experience considerable pressure. This pressure is, for vesicles of 0·01cm., 0·001cm., and 0·001cm., and 0·0001cm., semidiameter, expressed in heights of water column, equal to 30 metres, 300m. and 3,000m. respectively, or an excess of pressure of about 3·30, and 300 atmospheres. The density of the air in the vesicles would thus, of course, differ markedly from that of the outer air. With these pressures the air would also diffuse through the walls of the vesicle, and ultimately the vesicle would be turned into a drop. In view of these relations of pressure in the interior of a vesicle the possibility of formation of such is the more unlikely.

The objection that the existence of drops must result in a distortion of the contours of the objects is met by the experiment of Brücke, in which, by letting an alcoholic solution of mastic drop into water, a troubled medium is produced, which appears blue in incident light, yellowish-red in transmitted light, and, as microscopic examination shows, consists of extremely small balls of mastic suspended in the water. The objects which one sees in looking through the solution appear, indeed, little luminous and yellowish-red, but never distorted.

An explanation of the blue color of sky light and its polarization has been attempted by Tyndall, through a very interesting experiment. A tube closed with plate glass was exhausted of its air, and then filled with vapors of organic substances, as amylic nitrite, butylic nitrite, and a little air, to a pressure of $\frac{1}{10}$ atmosphere. The tube appeared perfectly transparent. When the beam of an electric light was sent through, clouds began to form in the tube through decomposition of the vapors by the chemically active rays of the electric light. These clouds give a deep blue color, which afterwards (the cloud particles having been enlarged by continued action of the light) tends to white. The blue light of the sky appears polarized, as one may easily observe with a Nicol's prism, looked through in a direction at right angles to that of the solar rays. The polarization plane of this light passes through the sun's ray and the observer. The vibrations take place at right angles to the solar and the visual ray. In directions which are not at right angles to the sun's rays the polarization is weaker.

The light sent out by the clouds formed in Tyndall's experiment is also polarized, and in a plane passing through the light ray and the visual ray. The maximum of polarization occurs here also when one looks at right angles to the light ray.

The blue light of the sky would, according to these experiments, be explained by extremely fine water particles floating in the air. The larger these fine particles are the whiter appears the firmament. In regions where the air is very dry—*e. g.*, in Persia—the sky is almost black if it is not troubled with dust. The assumption of fine water drops is adequate to explain all phenomena which have been attributed to the existence of mist vesicles, and that assumption, from its simple explanation of the formation of the fine drops through accumulation of the molecules, is much better warranted than that of the mist vesicles.

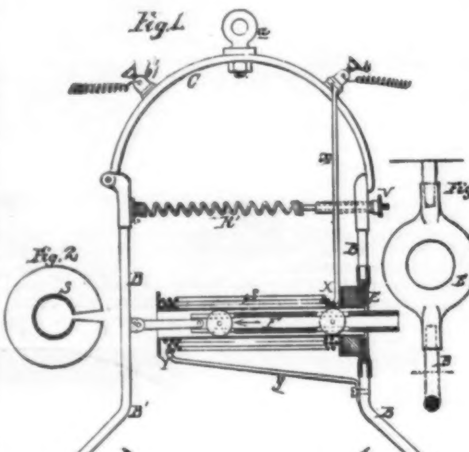
IMPROVEMENT IN ELECTRIC LIGHTS.

By Nicolas Emile Reynier, Paris.

A and A' are the circular disks or plates of carbon, secured to the central stem of the clock movements, M M', respectively, the latter motor being rigidly secured to the arm B', while the movement or motor, M, is hinged at O', to the arm, B, and is maintained by the spring, R, in contact with the set screw, *c*, by which the said motor and carbon plate, A, may be adjusted to the requisite angle. The arms B and B' are connected to an arch plate, C, which is furnished with a suspension hook, *a*, the arm, B, being rigidly secured to the arch, C, while the arm, B', carrying the carbon plate, A', is hinged to the arch at O. A spring, R, regulated by the thumb-screw, V, tends to cause the arms, B and B', and, consequently the carbons, A and A' to approach each other.

The arm, B, is separated into two parts by the non-conducting ring, E, to which is secured the bobbin of a solenoid S, and in the interior of this bobbin is arranged to slide the soft-metal bar, F, connected to the arm, B'. One of the wires of the electrical machine or battery is connected to the insulated binding-screw, *b*, which communicates with one end of the solenoid, at X, through the rod, *x*, while the opposite end of the solenoid communicates through the rod, Y, with the lower part of the arm, B, and through the latter with the carbon plate, A. The other electric wire is connected to the non insulated binding-screw, *b'*, and communicates, through the arm, B', with the carbon plate, A'.

I prefer to interpose a diaphragm, D, between each carbon and its motor, to protect the latter from the heat generated, whilst a small fan, *v*, operated by each motor, creates a constant current of fresh air.



IMPROVEMENT IN ELECTRIC LIGHTS.

The parts being in the position shown in Fig. 1, and the motors, M M', being set in motion, as soon as the electric circuit is formed the solenoid, S, will draw the soft metal bar in the direction of the arrow, and thus, against the action of the spring, R', will cause the carbon plates to separate, when the electric arc will appear, and a brilliant light be the result. The tension of this spring, B', being properly regulated, it will be seen that the more intense the electric current is the farther apart will the solenoid tend to force the two carbons; but as these carbons are consumed the distance between them would be increased and the electric current become less intense, did not the action of the spring accord with the intensity of the current, and always maintain the edges of the carbons at the same distance apart from each other. In other words, the carbons are caused, by the counteracting forces of the spring and the solenoid, to gradually advance toward each other in exact proportion to their consumption.

It will be seen, therefore, that by the above described construction I entirely overcome the objection to the ordinary electric lamps, in which the carbons are caused to approach each other intermittingly, and by having circular disks of carbon, to which a rotary motion is imparted, I obtain economy in construction, while the carbons last longer in proportion than the ordinary carbon rods, disks of the above described construction lasting from eighteen to twenty hours.

If an electrical machine or pile with reversed currents is used, the carbons may be of the same size; but where the current is continuous the negative carbon should be about two thirds as thick as the positive one, since the latter is consumed faster than the former. I have found that these carbon plates cannot well be made of the ordinary retort carbon, and consequently I use a compound of about one hundred parts of carbon to twenty parts of sugar and five of iron filings.

I also cover the upper surface of each carbon with a plate of metal, nickel or copper, in order to prevent the electric arc from rising in the angle between the two carbons, and also to reflect the small portion of the light which does rise therein.

EDISON'S PRESSURE RELAY.

Mr. Edison has recently invented an ingenious and novel relay instrument, based upon an entirely new principle. He takes advantage of the property which plumbago possesses of decreasing its resistance enormously under slight pressure. Thin disks of that material are placed upon the cupped poles of an electro-magnet, the coils of which have several hundred ohms resistance. Upon the disks of plumbago is laid the armature which is provided with a binding post for clamping the local battery wire.

The cores of the magnet, the plumbago disks, and the armature are included in a local circuit, which also contains an ordinary sounder and several cells of bichromate battery. The relay magnet is inserted in the main line in the usual manner. The operation is as follows: When the main circuit is opened the attraction for the armature ceases, and the only pressure upon the plumbago disks is due to the weight of the armature itself. With this pressure only the resistance of the plumbago to the passage of the local current amounts to several hundred ohms; with this resistance in the local circuit the sounder remains open. If now the main circuit be closed, a powerful attraction is set up between the poles of the relay magnet and its armature, causing a great increase in the pressure upon the plumbago disks, and reducing its resistance from several hundred to several ohms; consequently the sounder closes. So far the result differs but little from the ordinary relay and sounder. But the great difference between this relay and those in common use, and its value, rests upon the fact that it repeats or translates from one circuit into another, the relative strengths on the first circuit. For instance, if a weak current circulates upon the line in which the relay magnet is inserted, the attraction for its armature will be small, the pressure upon the plumbago disks will be light, consequently a weak current will circulate within the second circuit; and on the contrary, if the current in the first circuit be strong, the pressure upon the plumbago disks will be increased, and in proportion will the current in the second circuit be increased. No adjustment is ever required. It is probably the only device yet invented which will allow of the translation of signals of *variable strengths*, from one circuit into another, by the use of batteries in the ordinary manner. This apparatus was designed by Mr. Edison for repeating acoustical vibrations of variable strengths in his speaking telegraph, a description of which we shall shortly publish.

Some men who were operating a threshing machine near Freehold, N. J., were prostrated by lightning. When they recovered their senses they found that the horse was dead, the machine destroyed, and 600 bushels of wheat in a blaze.

CAPILLARY ELECTROMETERS.

In our notices of the late Loan Collection of Scientific Apparatus at South Kensington, we described the principal forms of those electrometers which depend for their principle upon the repulsion or attraction which invariably takes place, or tends to do so, between two neighboring conductors, similarly or dissimilarly electrified, when either or both are free to move; and we there referred to a small but very interesting class of instruments differing altogether from those previously described, their indications depending upon a different principle.

To this class belong the electrometer of Lippmann and the modifications of it which have been devised by Marey, Jung, Professor Dewar, and others, and which are in principle based upon the discovery made by Lippmann in 1873, that minute differences of electrical potential can be detected and measured by the alteration of tension of the surface separating mercury from diluted sulphuric acid which accompanies changes in the difference of potential between those substances.

Lippmann's electrometer, which is represented in Fig. 1, consists of a vertical glass tube about a metre in length and seven millimetres in diameter, drawn out at its lower end to a fine capillary point of a diameter of only a few thousandths of a millimetre. This capillary end dips into diluted sulphuric acid (one part of acid to six of water) which floats upon a substratum of mercury contained in a cylindrical glass vessel rigidly fixed below the vertical tube, into which mercury is poured to a height at which its vertical pressure is sufficient to force mercury into the capillary portion of the tube, but not enough to cause it to escape through the capillary orifice; this height is, more or less according to the diameter of the fine tube, about 750 millimetres (29½ in.). The small portion of the tube is curved and presses against the vertical side of the cylindrical vessel so as to be in the focus of a microscope fixed in a horizontal position opposite to it, and which magnifies about 250 times linear. This microscope is mounted on a little tripod supported by leveling screws arranged on the "hole, groove, and plane" principle of Sir William Thomson, that is to say, of the leveling screws (all of which have their points rounded), one rests in a little triangular conical cup, another in a longitudinal V-shaped groove, and the third on a plane surface, so that the position of the microscope in azimuth is accurately defined and all tendency to vibration is eliminated. The eyepiece of this part of the apparatus carries a micrometer, and by it the position of the meniscus which terminates the mercurial column in the capillary tube can be measured with extreme accuracy.

The mercury in the vertical tube is in metallic communication with one electrode of the instrument, the other electrode being connected with the mercury in the lower vessel. The upper portion of the vertical tube communicates by a flexible tube with a small air press placed below the stand of the electrometer, and is actuated by a handwheel or lever (see Fig. 1). By this contrivance the pressure above the mercury may be varied at pleasure, its amount being indicated by a siphon manometer connected to the air-press by another flexible tube, and mercury may by it be forced through the capillary point.

Upon connecting the positive pole of a voltaic couple with

the lower electrode of this electrometer, and the negative pole with the upper electrode, the mercury in the capillary tube retreats from the orifice, the amount of its displacement being dependent on the pressure of mercury at that point, and the electro-motive force of the couple. In measuring the electro-motive force of a voltaic element the meniscus at the lower limit of the mercurial column is forced back to its original or zero position seen in the micrometer eye-piece, the pressure required to do so being indicated by the reading of the manometer which bears a relation to the electrical forces which forced the mercury back, and therefore to the difference of potential between the two poles of the couple to be tested. An example of this instrument formed part of the recent Loan Collection of Scientific Apparatus.

Fig. 2 represents the modification of Lippman's electrometer devised by Professor Marey, which is employed by Dr. Burdon-Sanderson, F.R.S., in his researches upon the electrical disturbances which accompany muscular and certain sensitive movements in plants and animals. It consists of a horizontal tube A drawn to a capillary point (about one-hundredth of a millimetre in diameter), which dips into diluted sulphuric acid in the larger horizontal tube B; the further end (which contains mercury, kept from flowing out by a plug of cotton wool at C) has fused into it a platinum wire connected to the electrode N of the instrument. The capillary tube A also contains mercury which can be put under pressure by the screw clamp E which presses on a small bag of india rubber, the clamp being actuated by the mill-headed screw F. The mercury contained in A is in connection with the electrode M. The two electrodes can, by a connecting piece P, be "short circuited," so as to keep them at the same electrical potential when necessary. Both tubes are rigidly attached to a frame which slides in dovetail guides, longitudinal motion being given to it by a micrometer screw O bearing against one end of the slide which is pressed up to its work by a spring bearing against the other end. The whole instrument measures but 8 in. by 1½ in., and is second galvanometer, and as the minute electro motive force of an organic tissue or structure has to be measured instead of that of a voltaic couple, certain modifications of the potentiometer have to be made in order to adapt it to so delicate an investigation.

The potentiometer of Mr. Latimer Clark consists of a vulcanite cylinder, which revolves on its axis like a Wheatstone's rheostat. Around this cylinder is wound about ten metres of platinum or platinum-iridium wire, about half a millimetre in diameter; the ends of this wire are connected to the axes of the cylinder, which work in blocks of metal and in mercurial contact with them. The electrical arrangements are so disposed that a sliding contact piece, by touching the coil at any point in its length, so varies the resistance of the circuit that a position is readily found at which the electrical potential is exactly the same as that of an interposed electro-voltaic cell whose electro-motive force is to be measured, this position being indicated by the galvanometer remaining at its zero position, showing that no current is passing through it, or that all displacing forces are neutralized.

The forces which are the object of the physiological researches of Dr. Burdon-Sanderson are, however, so exceedingly small, as compared to those produced in voltaic arrangements, that a modification of the potentiometer had to be made in order to adapt it to such small measurements as that of the electro-motive force developed between the base and apex of a batrachian heart, or of electro-motive forces very much smaller still. In the potentiometer employed for this investigation the sliding contact piece works on the last twentieth of the length of the wire, the divisions indicated by its index and scale representing fractional parts, not of the whole wire but of the last twentieth of its length.

On referring to the diagram, Fig. 3, it will be seen that the two blocks of the potentiometer, or, in other words, the extreme ends of the wire coil, are connected up with two separate batteries in such a way that they both send a cur- Mr. F. J. M. Page, has found that when the heart is at rest, the electrical potential of its base is slightly positive to that of its apex, but at about one-sixth of a second before muscular contraction takes place, this difference of potential is suddenly reversed, the movement of the mercury in the electrometer indicating that at that instant the apex becomes positive to the base.*

In concluding this subject, it may be well to say that the standard voltaic cell of Mr. Latimer Clark consists of a glass vessel containing pure distilled mercury as the negative element, which is covered by a paste made by boiling mercurious sulphate in a saturated solution of zinc sulphate. Upon this paste rests a disc of the purest distilled zinc, which forms the positive element.†

Professor Dewar's electrometer (also founded upon Lippmann's discovery) consists of two cylindrical glass vessels containing mercury, upon which floats diluted sulphuric acid. These vessels are connected together by a horizontal glass tube, bent down at right angles at each end so as to dip into them, and containing mercury. When the mercury contained in the two vessels is at the same electrical potential, a globule of diluted acid in the horizontal portion of the tube, which serves as an index to the instrument, and which separates the column of mercury into two portions, remains at the center or zero point of the tube; but if there exist any difference of potential between the two vessels there is at once established a difference of surface tension between the opposite ends of the globule, causing it to move along the tube towards that vessel which is at the lower potential, the amount of its displacement being indicated by a scale placed behind the tube.

In a more recent form of this instrument, which we illustrate in Fig. 4 on the preceding page, Professor Dewar dispenses with the two upright portions of the connecting tube, leaving only the central horizontal portion, the two ends of which pass through the sides of the cylindrical vessels little below the surface of the mercury.

FIG. 1.

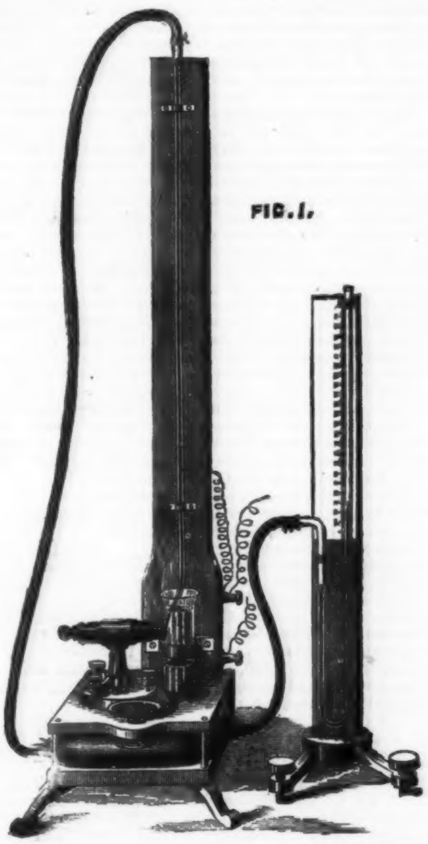
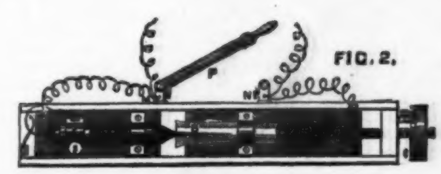


FIG. 2.



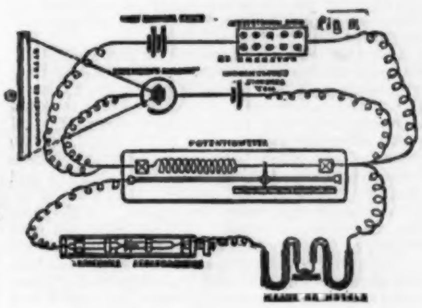


FIG. 4

ILLUSTRATIONS OF CAPILLARY ELECTROMETERS.

placed on the stage of an ordinary microscope, the eye-piece of which is furnished with a micrometer which constitutes the scale of the instrument.

In observing with this electrometer the two electrodes are connected together, and the pressure in the capillary tube is first increased by the clamp E until mercury escapes from the fine point, and then diminished, when the meniscal surface retreats to a certain position, the micrometer being so adjusted that its zero line appears tangential to this surface; the instrument is then at its zero or starting position. Upon disconnecting the two electrodes from one another, and connecting them respectively with any electromotive arrangement or structure interposed between them, the meniscus in the capillary alters its position, retreating from the point if the body to which it is connected be at a negative potential and moving towards the point if the potential of the body be positive. The difference of tension thus indicated might be estimated, as in Lippman's instrument last described, by measuring the difference of pressure necessary to bring the mercurial index back to zero, but Dr. Burdon Sanderson finds it more convenient to measure the difference of surface tension by observing the distance travelled by the meniscal surface from its zero position; and by means of the micrometrical arrangements to which we have referred, this distance may be accurately measured the one-hundredth part of a millimetre.

Fig. 3 is a diagram illustrative of the arrangement adopted by Dr. Burdon Sanderson in his electro-physiological researches for measuring the electro-motive force developed in plants and animals at the moment of muscular and other contractile movements. This arrangement is almost identical with that devised by Mr. Latimer Clark for comparing by means of the potentiometer the electro-motive force of a of a voltaic couple with another couple whose electro-motive force is known, which method is based on that originally devised by Poggendorff for the same purpose. The chief points in which Dr. Burdon-Sanderson's latest arrangement differs from Mr. Latimer Clark's are that Dr. Burdon Sanderson employs Lippmann's electrometer in the place of a rent through the coil in the same direction. The circuit of the more powerful battery (two Daniell cells) has interposed in it a resistance or rheostat by which its strength can be varied, and in the other circuit there is a Thomson's galvanometer. From this arrangement it is clear that if the difference of potential maintained by the Daniell battery between the two ends of the coils of the potentiometer be greater than that of the standard cell, the battery will overpower the cell and send a reversed current through it; if, on the other hand, the difference of potential be less, then both the battery and the cell will jointly send a current through the coil. By adjusting the resistance in the battery circuit by means of the resistance box or rheostat, the difference of potential between the two ends of the coil can be made exactly equal to that between the poles of the standard cell, no current passing through the galvanometer and the standard cell remains inactive; it is, therefore, in a condition to be compared with the electro-motive force of a muscle, heart, or other electro-motive structure under investigation, which is placed on a small glass plate, and in order to avoid local voltaic action in the heart itself it is connected in the circuit of the rest of the apparatus by means of unpolarizable conductors, which consist of silk threads moistened with sodium chloride. In the case of the heart these threads are tied round the base and apex of the organ respectively, and pass into syphon tubes filled with Stourbridge clay, which are impregnated with a solution of sodium chloride, and which constitute the electrodes of the instrument. When it is desired to keep the muscular vitality in action for a considerable time, the apparatus containing the muscular structure must be inclosed in a glass chamber, the atmosphere of which is kept saturated with moisture. One of these electrodes is connected to one end of the electrometer, and the other electrode to the other end through a portion of the potentiometer, the length of which is determined by the position of the sliding piece on the scale, and which gives the value of the electro-motive force of the structure under investigation in terms of proportional parts of the standard cell. Dr. Burdon-Sanderson, with whom has been associated

With this electrometer, which is constructed by Messrs. Tisley and Spiller, Professor Dewar states that it is possible to indicate and measure an electro-motive force equal to that of one ten-thousandth part of a Daniell's cell.—*Engineering.*

RED OR GREEN?

HOWEVER difficult it may be to get ideas into the heads of some people, it is confessedly much more difficult, when once they are there, to get them out again. I heard a good illustration of this some time ago, when in conversation with an extensive copperplate printer who was laboriously endeavoring to introduce a method of photo-mechanical printing into his business. He said: "There is no difficulty with the process when I work it myself or stand over the printers while they are at work; but the moment my back is turned they fall into the way of working to which they have been trained, and so spoil all. What I want, and find most difficulty to get, is *wooden-headed* men who will leave the thinking to me, and do just exactly as they are told."

In nothing, perhaps, is this difficulty of unlearning more frequently seen than in the pertinacity with which *yellow* is claimed as one of the primary colors, and green, "nature's glorious garb," degraded to a mere secondary. Men who are well up in scientific matters generally, and who know also a good deal about the beautiful laws of light, are found writing of the primaries as *red, yellow,* and *blue,* instead of *red, green,* and *violet,* and that too, in spite of the fact that a little consideration and a few simple experiments would make it abundantly clear that the earlier writers were wrong, and Young, Herschel, and Clerk Maxwell right. Curiously enough, also, the principal fact on which the erroneous opinion is often based—the production of a green by the mixture of yellow and blue pigments—is, when properly

* For the researches of Dr. Burdon-Sanderson on the electrical disturbances developed in the leaf of the Dionæa, see *Proceedings of the Royal Society*, No 177, 1876.

† For a full description of this standard battery, see *Philosophical Transactions*, vol. 164, page 1.

considered, one of the clearest proofs of the fallacy of the notion. In connection with this subject, I once heard the late Sir George Harvey, President of the Royal Scottish Academy, declare before a meeting of the Royal Scottish Society of Arts that so long as he could produce a green on his palette by a mixture of yellow and blue, it was little better than presumption for any mere theorist to try to lecture him into the belief that green was a simple color.

In discussing questions of this kind we occasionally hear it said that it is no great matter how they are expressed so long as the intention of the writer is thoroughly understood; but truth is truth, and surely to a photographer, whose very existence depends on light, and whose most brilliant discoveries yet to be made may depend on the correct appreciation of that truth, the question is of the utmost importance.

But, simple as the question is, I cannot expect that the editors would allow me sufficient space for anything like a exhaustive *resumé* of the present position of our knowledge of it, the more especially as it will be found plainly laid down in the works of the writers already mentioned. I shall, therefore, confine myself to the suggestion of one or two experiments that, to my mind at least, make the matter quite clear, and refer those interested in the subject to the works of the writers to which I have referred.

And, first, let us try to dispose of the mixed blue and yellow pigment evidence. No doubt the best way to experiment in this direction would be to pass sunlight through a prism or prisms, receiving the separated rays on an arrangement of narrow mirrors placed side by side, and capable of being each turned to various angles. In this way the various rays could be further separated, or made to combine on a suitably-placed screen; but those for whom I am especially anxious to write have not generally the necessary convenience for such arrangements, and sufficiently convincing results may be arrived at in simpler ways. Colored glasses, if the pure tints could be obtained, would be most easily manipulated; but I have always found much difficulty in getting glass in anything like pure colors, and so I generally have recourse to gelatine films, which are easily got, cost little, and answer tolerably well, being readily made to adhere to a glass plate, stripe over stripe, in any desirable position. Probably the simplest plan is to use a pane of a window on which to place the colored stripes, which may conveniently be about five inches long by one inch broad.

Suppose, then, that on such a pane we fix perpendicularly the stripes—respectively red, green, and violet—keeping them an inch apart, and over them, horizontally, a yellow and a blue. If the yellow were a primary color it would necessarily be opaque to the red and to the violet, as it could only pass rays vibrating at the same rate as itself, and so only the yellow of the green, supposing the green to be a secondary color, could be transmitted. But both red and green are found to pass through readily, thus proving the yellow to be a compound of those two colors. In the same way the blue, if a primary, should, if a stripe be laid over the yellow one, be opaque to the green that had passed through it; but, in reality, the green passes through the blue also, showing unmistakably that blue is a compound of green and some other ray. In other words, while the yellow film stops certain rays, and the blue is opaque to certain others, both agree in passing green, thus showing that green enters into the composition of both.

On the first introduction of Clerk Maxwell's "color top", much disappointment was felt at the inability to produce the supposed secondary, or compound, green by combining the yellow and blue rays; but the foregoing experiment proves that when that color is produced by the mixture of pigments it is not effected by a combination of the rays, but is due solely to the fact that the yellow passes the red and green while stopping the rest, and the blue stops the red but passes the green. A slight examination of various blue substances by means of a prism will also make it abundantly clear that that color consists of green with the rays of greatest refrangibility, and forces the observer to the conclusion that the primary colors are red, green, and violet.

Those who have the convenience, or who may be inclined to go to some little expense in the investigation, may, by aid of the prism and set of mirrors already mentioned, illustrate in the most satisfactory manner the cardinal facts—that by no possible combination of colored rays can either red, green, or violet be obtained, while by the union of the violet and green and the green and red, respectively, the most brilliant blue and yellow is produced.—*John Nicol, Ph. D., in British Journal of Photography.*

PHYSICAL SOCIETY, LONDON.

Professor G. C. Foster, F.R.S., President, in the Chair.

Optical Bench.—Prof. W. Grylls Adams exhibited and described a very complete form of optical bench, which, in addition to being provided with all the improvements introduced by Prof. Clinton, carries an arm which can be set at any angle to it, and is provided with appliances for studying a beam of light or radiant heat when it deviates from the main axis of the instrument. At the base of a pillar firmly clamped in any position in the manner adopted by Prof. Clifton, is fixed a horizontal graduated circle, and a vernier attached to a counterpoised arm, which rotates round the axis of this pillar, renders it possible to determine the angle made by the arm with the bench to one minute. At the upper extremity of the pillar is a steel pivot to which various appendages may be clamped, and immediately below this is a second graduated circle by which to determine the angular position of whatever is supported by the pillar. Mirrors, metallic surfaces, prisms, etc., may be placed on this pillar for the reflection, refraction, diffusion, or polarization of heat and light. For radiant heat the rotating arm carries a line, thermo-electric pile, and a table on which absorbing media may be placed. Prof. Adams illustrated the use of the instrument by projecting on to a screen the interference bands obtained when a beam of light, after reflection from the two surfaces of a thick plate of glass, is again reflected from the two surfaces of a similar plate placed very nearly but not quite parallel to the first. A compensator, consisting of two plates of glass of equal thickness, is also added between the two thick plates, and an ingenious arrangement renders it possible to incline the glasses at any angle to one another, and to move them either independently or together. He also showed the delicate adjustment of which this compensator is susceptible and the effect produced in the positions of bands when the rays from the two surfaces of the first plate traverse air of different densities before falling on the second. The adjustment of this latter was facilitated by fine screws supplemented by springs, which rendered it possible to give a slight movement to the plate in any direction by combining a motion of translation of the plate parallel to its reflecting faces with a motion of rotation about a vertical or horizontal axis.

Thermometers.—Mr. F. D. Brown exhibited an apparatus he has arranged in which to compare thermometers, and which is also applicable to other cases requiring a limited space to be retained at a perfectly uniform elevated temperature. From a brass hemispherical boiler rises a tube of the same metal, 2 inches in diameter and about 2 feet long; the steam, after ascending through it, descends a metallic jacket surrounding it, whence it passes into a U-shaped condenser, and from this it is returned to the boiler. The upper end of the condenser is in connection with a large air-tight vessel forming the base of the apparatus, and in which any required degree of exhaustion can be maintained by the use of Lothar Meyer's form of pump. The thermometers are placed in tubes containing liquid, which pass within the wide brass tube at its upper end, and by varying the nature of the liquid in the boiler and the pressure to which it is subjected the boiling-point can be retained constant at any required temperature.

Electrical Selection.—Dr. Guthrie and Mr. Akroyd communicated a paper on electrical selection. When a metal or other body is rubbed against some non-conducting substance like caoutchouc, electricity is developed, and the track of the metal, although invisible, may be readily made evident by sprinkling on the caoutchouc a mixture of red-lead and sulphur. This sieving, as is well known, imparts negative electricity to the sulphur and positive to the red-lead; hence, by a kind of electrical selection, that particular ingredient of the mixture is drawn to the metal track which possesses the opposite kind of electricity. Iron, for example, when rubbed against caoutchouc, generates negative electricity, and, after sprinkling the powder, the iron track is revealed by the marked collection thereon of red-lead. A list of mixtures was given which may be used instead of the above, and it is shown that electrical selection may prove of use (1) in making an electrical diagnosis of the metals, (2) in certain experiments where the quadrant electrometer is objectionable, and (3) in teaching, where this instrument is often unavailable on account of its cost.

STATISTICAL SOCIETY, LONDON.

At a recent meeting, Mr. E. G. Ravenstein, F. R. G. S., read an elaborate paper on "The Populations of Russia and Turkey." The former of these empires has 84,584,482 inhabitants, the latter only 25,986,868, or, including Egypt, Tripoli, and Tunis, 43,408,900. The population of Roumania is 4,850,000; of Servia, 1,352,500. The population of Russia increases at the rate of 1·1 per cent per annum, the increase among the Jews being at least double what it is amongst the Christians. With respect to Turkey, there exist no data for calculating the increase, though it is most probable that the dominant race does not increase at all, a fact accounted for by vicious practices prevailing amongst the women, and by the sacrifices demanded from it for the defence of the empire. Some curious facts were communicated with respect to the proportions between males and females. Throughout Asiatic Russia and in a considerable portion of European Russia the male sex preponderates. The same fact has been noted in Roumania, in Greece, and in other parts of Europe. The author thus summed up the results of his investigations: In the Russian empire there are 100 Russians to every 55 members of other nationalities, and 100 Christians to every 16 Mohammedans and Pagans. In Turkey, on the other hand, 100 Turks have opposed to them 197 members of other nations, and 100 Mohammedans to 47 Christians. The advantage, in both these respects, is therefore entirely on the side of Russia, and the position of Turkey must appear in a still less favorable light, if we look at the details of the geographical distribution of the dominant race and religion, and bear in mind the interest existing amongst Slavs and Greeks on behalf of some of the races dwelling within the limits of that empire. After the reading of the paper, a number of diagrams, illustrating the accounts of the banks of England, France, Germany, Austria, Belgium, Holland, and Russia, were exhibited, and remarks made thereon by Mr. E. Seyd, F. S. S.

CALIFORNIA ACADEMY OF SCIENCES.

At a recent meeting, from J. A. Hosmer a skull and stone mortar were presented. They were found on Anacapa island, at the base of an artificial shell mound, the mound one of a number, and the shells chiefly those of abalone and mussel. Fragments of flint were scattered around, evidently left there by arrow-makers. Fossils of leaves from Blue Tent, Nevada County.

HAIR SNAKES.

Mr. J. R. Scupham presented two bottled specimens of the *Gordius*, or hair snake, which is not uncommonly found in railway station tanks. One of the specimens, Mr. Scupham said, illustrates the readiness with which a mistaken opinion may be formed on the growth of these filamentous creatures. The two specimens exhibited were placed in a bottle and kept there two or three days, when it was discovered that a long white substance had been developed, apparently a progeny of young *Gordii*. In a little while there was a further increase, and the parties brought the bottle to him for examination. The real history of the animal's development is, that it lays eggs in the water, and these eggs require to be taken up by some insect, such as the cricket or the spider. From the egg they pass into the larva state, and then the insect has to die before the *Gordius* can be developed and come to perfection. The chances are one in 200,000 that all this will not occur, so that 200,000 eggs fail for one that reaches maturity. The creature provides for this by depositing more than this number of eggs. He had examined the specimen with the microscope, and found that in a very small part there is a multitude of ova, probably upwards of 200,000.

Mr. Stearns read a sketch of the life of Colonel Ezekiel Jewett, a soldier and scientist, who died at Santa Barbara last May, at the age of 86 years. Deceased served with General Scott in the Canadian campaign of the war of 1812, afterward under the flag of Chile in the revolution from the domination of Spain, and in latter years became a scientist of note and high repute in the field of geology and paleontology. He was also an eager student of conchology.

MT. DIABLO COAL.

Mr. S. B. Christy, of the University of California, read some "Notes on the Mt. Diablo Coal Mines." It was valuable as giving an analysis of the various grades of coal in the Mt. Diablo field, and in those of Livermore and Washington Territory. In the Mt. Diablo beds coal is chiefly taken from two veins, the Clarke and the Black Diamond. These lie about 400 feet apart, though sometimes at a greater distance. They are nearly parallel and have a strike northeast and west, with a dip of from 20° to 30° to the north. As usual, they lie between beds of sandstone, which change into bituminous shale as they approach the veins. The roof frequently shows impressions of leaves. Between these larger beds are numerous thin streaks of coal, most of which disappear; but one of them, the so-called middle vein, increases in size to the east, until nearly as large as the Clarke vein itself. At the Black Diamond mine the Clarke vein is three feet thick, and at the other mines from two feet to two feet six inches. The Black Diamond vein is eight feet thick, but only four feet are workable, the rest being bone. Difference in brightness, color and luster make it only a matter of eyesight to separate the two coals when mixed on the dump. It is said the Clarke coal takes fire more readily, whilst the other gives more heat. Both crumble readily and are sulphurous. The acid sulphates they contain render the coals unsuited for use in boilers. The ligneous qualities of the deposit were pointed out, and the results of analysis given in connection with specimens from Livermore and the north. The Livermore coal, it was stated, has too much water and ash in its composition to be valuable, while some of the coal north is of fine quality.—*Mining and Scientific Press.*

EUROPEAN LABOR.

A paper has lately been published in London giving, from authentic sources, information upon this subject, from which we summarize some important and interesting facts for our readers. It appears that the regular standard of laborers' wages throughout Europe will not average more than thirty cents per day, and scarcely ever exceeds fifty cents. The laboring men and women of Russia, Germany, France, and England toil in the fields from sunrise to sunset for a sum scarcely sufficient in this country to purchase a roll and a cup of coffee. In Austria the average rate of laborers' wages is, in Summer, about twenty cents, while in Winter it is less than this. For women the highest rate is fifteen dollars per year and board. In Denmark the laborer receives from ten to twenty cents per day and board, or thirty cents and boards himself. In France thirty-five cents per day is considered excellent pay for men, and half that sum for women, the latter performing much of the field labor.

In Prussia wages range from twelve to twenty cents per day for men, and ten to eighteen for women, with house rent and garden free. In Saxony, Bavaria and Wurtemburg daily wages average from twenty to thirty-five cents with board, consisting of bread, cheese, vegetables, coffee and beer. In Italy the Lombards work for thirty cents per day and board themselves, the Bolognese for twenty and twenty-five. In the Netherlands the standard of labor is still lower, amounting to sixteen or eighteen cents per day. The Russian laborer works from four in the morning until dark at night for eight and ten cents per day if engaged by the year, and twenty cents if employed by the day. In the height of harvest time these rates are increased. The diet of the Russian field hand is cabbage, baked buckwheat, oil and rye bread. In the different provinces of Spain wages rarely exceed thirty cents per day. The diet is very poor—bread and vegetables with cucumber soup. In England, though the wages seem poor compared with this country, there is a decided difference in favor of the laborer, wages averaging from fifty to seventy-five cents per day, and the same may be said of Scotland, while in Ireland the pay is considerably less, but varying in the different sections.

The American day laborer (we do not speak of mechanics) finds it hard to realize these facts, while he receives two dollars per day, and oftener more than less. The low rates of wages in Europe and the difficulty of obtaining a comfortable living at home is the direct cause of the immense emigration to this country, now, to be sure, a little checked, owing to the stagnation in business which we have lately experienced. Year by year the strong-handed Irish, the sturdy German, the sober, industrious Swede, the ingenious Swiss and the very flower of the industrial class of the Old World come hither to establish new homes, and, while benefiting themselves, they surely add to the material wealth of the United States.—*Boston Cultivator.*

FRAUDS ON LIFE INSURANCE COMPANIES.

In a recent address before the Life Underwriters' Association, Dr. C. C. Bombaugh, Ohio, spoke of some of the means used for suicide: There are toxical agents, which are at the present time absolutely beyond the reach of chemical or microscopic analysis. There are deadly substances—not readily accessible, we admit—which act so quietly, as nerve poisons, muscle poisons, or blood poisons, that it would be easier to trace the marsh miasm voluntarily inhaled that it might end in a fatal remittent, or apply an inquisitorial probe to exposure deliberately courted that it might be crowned with irremediable mischief. Some of these poisons, like the wourali of Guiana, for instance, abolish the power of the nerves of motion; others, like the corroval with which arrows are envenomed in Panama, palsy the action of the heart; and others, like carbonic oxide, destroy the function of the red globules of the blood. A chip from a Calabar bean is potent enough to make a large cavity in the money-bags of a company, while the death-dealing juices for which Java and Australia are unenviably noted, laugh to scorn such self betraying drugs as morphia, or strychnia, or aconite, or prussic acid. Your calculating, methodical, and self-disciplined suicide of the future will not make the mistake that the Belgian poisoner, Count de Bocarmé, made in killing his brother-in-law. After studying chemistry with a famous teacher, he fitted up at home an apparatus for the distillation of nicotine, stupidly thinking that thereby the game was in his own hands. But his nicotine led him to the gallows. Some of you will remember an Hungarian romance that recently came to light. Baron Olnyi, a few years after marriage to a most estimable lady, to whom he was devotedly attached, lost his property, amounting to two millions, in speculation. When he realized his utter ruin, he obtained insurance on his life to a very large amount. He then had recourse to a plan of slow poisoning, and died in about ten months. Subsequent investigations unfolded the mystery. He had rented a small apartment in a remote and obscure part of the city of Pesth, and there spent his entire time, except that appropriated to meals and sleep at home, in smoking enormous quantities of the strongest tobacco he could procure, until his nervous system was shattered, and torpor and prostration ended in dissolution. But he left behind him the telltale witness—smoking-cap and gown, pipes and cigars, reclining seats, and chests containing tobacco enough to stock an establishment. When your coming suicide concludes to saturate himself with nicotine in this way, he will turn cap and gown and all else into smoke before he goes home for the last time. Or if he prefers a dose of lead, he

will make his pistol tell a story of accident, or of discharge in the hands of some other person, that will deceive the very elect.

THE FLAG, AND OTHER FLAGS.

AT Portsmouth, N. H., on June 14th, there was an interesting celebration of the centennial of the adoption of the national flag, the standard known now throughout the world as the symbol of the great republic. It was on the 14th of June, 1777, that a resolution passed the Continental Congress, decreeing "that the flag of the 13 United States be thirteen stripes alternate red and white; that the Union be 13 stars white in a blue field, representing a new constellation." This is the first action of which there is any record concerning the national flag, and this was not promulgated officially until the 3d September following, although the newspapers, then, as now, apt to anticipate official announcements, printed the resolution a month before that time. On the same day that Congress passed the resolution establishing the design of the national flag, another resolution was adopted appointing Captain John Paul Jones to command the Ranger ship of war, and it was also resolved "that William Whipple, esq., member of Congress, and of the marine committee, John Langdon, esq., continental agent, and the said John Paul Jones be authorized to appoint lieutenants and other commissioned officers, and warrant officers necessary for the said ship." The Ranger, a sloop of war carrying eighteen six-pounders, was built on Badger's island in Portsmouth harbor, and had been launched in May preceding the passage of these resolutions. Captain Jones sailed in her from Portsmouth, and on the 2d December following he arrived at Nantes in France. Sailing from that port he arrived at Brest on the 13th February, 1778, where he saluted the French admiral, Count d'Orvilliers, with 13 guns, and the salute was returned with 9 guns, which was the first salute of honor which the American flag, for it is supposed Jones carried the new flag, received from a foreign man of war. John Langdon, the Continental agent, lived in Portsmouth, and it is assumed as probable that the flag was first raised in that city. It is in accordance with this assumption that the city has undertaken to celebrate the anniversary of the adoption of the flag with appropriate ceremonies. There is something a little shadowy, perhaps, in Portsmouth's claim, but we do not suppose there is any disposition to dispute it.

When the American colonists began to think, or rather began to act, in organized hostility to the mother-country, they did not at first reject the English flag, but made it serve their purpose by emblazoning on it a motto. The newspapers of 1774 have much to say about "Union Flags." These were the ordinary red ensign of England, bearing the union jack, and generally some patriotic motto, as "Liberty," "Liberty and Property," "Liberty and Union," etc. After the Concord fight, the Connecticut troops put on their standards the State arms and motto. It is not known what flag, if any, was raised by the Continentals at the Bunker Hill, but on the 18th of July following, General Putnam displayed on Prospect Hill a red flag with the motto of Connecticut, "*Qui transtulit, sustinet*," on one side, and on the other the words "An Appeal to Heaven." In April, 1776, the provincial Congress of Massachusetts adopted the last motto as the one to be borne on the flag of the cruisers of the province, which was a white flag with a green pine tree. Another pine tree flag was red in the body of it, and had the tree on a white ground in the corner where now are the stars. The flag of Fort Moultrie was blue with a white crescent in the upper corner next the staff, as we had opportunity of seeing two years ago when the Charleston Light Infantry brought it to this city.

On the 2d of January, 1776, Washington raised at Cambridge a flag of thirteen alternate red and white stripes like the present flag, with the crosses of St. George and St. Andrew on the blue ground in the upper corner. This was called the "Great Union," and was much used in the colonies. It was carried by the fleet under command of Commodore Hopkins, which sailed from the Delaware capes the 17th of February, 1776. Very likely it was this flag borne by the Andromeda, which was saluted in November, 1776, by John de Graff, governor of the Dutch island of St. Eustatius in the West Indies. There is good reason to believe that he saluted an American cruiser bearing a flag, but the flag could hardly have been the "Stars and Stripes," as sometimes claimed, inasmuch as that flag had never yet floated on the breeze, or, indeed, so far as known exists in anybody's imagination. The State of New Hampshire owns a portrait of Governor de Graff, and some interesting documents concerning his action and the trouble he got into on account of it have been published.

When Commodore Hopkins raised the "Great Union" he discharged a yellow ensign, bearing a rattlesnake in the act of striking, with the motto, "Don't tread on me." There were many designs of the rattlesnake flag, which had great popularity. The origin of the grand Union flag is not known. It is believed that the thirteen red and white stripes were first employed on a banner presented in 1774 or 1775 to the Philadelphia troop of light horse by Captain Abraham Markoe, and still in possession of that organization. The emblem of the British flag, the blended crosses, was retained in the flag even after the declaration of independence, until the stars were substituted by the resolution just quoted. Who suggested the stripes and who the stars is not known, but the suggestion of the stars has been attributed to John Adams.

In the early flags, the thirteen stars were arranged in a circle, but the arrangement was not officially prescribed. No change was made in the flag until 1794, when, on motion of Senator Bradley of Vermont, Vermont and Kentucky having been added to the Union, Congress enacted that it should consist of fifteen stripes and fifteen stars. That was the style of the flag for more than twenty years, until 1818. In 1816 a committee of Congress was appointed to inquire into the expediency of altering the flag. While the matter was under consideration, Captain Samuel C. Reid, of the Navy, recommended the reduction of the stripes to thirteen, making the number of stars equal the number of States, all to be formed into one large star, and a new star to be added for each new State on the 4th July next succeeding its admission to the Union. A bill embodying these suggestions, except as to the arrangement of the stars, passed Congress and was approved by the President on the 4th April, 1818, and on the 13th the new flag was raised over the house of representatives, although it did not become the legal standard until the 4th July. In 1859 Congress, by a vote of thanks, recognized the service of Captain Reid as the designer of the national flag. The war department sometimes follows Captain Reid's suggestion in the arrangement of the stars, but in the navy flags they are always arranged in parallel lines.

Now, after a hundred years, the flag adopted a century ago to-day, unchanged except by the addition of stars representing new States, floats over a united nation ranking as one of the great powers of the earth, and surpassing in vastness of territory, in population, in prosperity, in happiness, in achievements, and in hopes, the brightest anticipations of its daring founders.

And the star-spangled banner, oh long may it wave
O'er the land of the free and the home of the brave!

—*Boston Advertiser.*

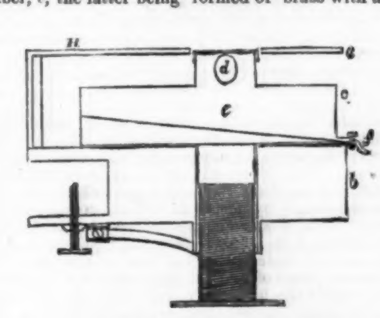
FORESTS OF SWEDEN.

THE principal part of the timber of the Swedish forests, according to the *Chronique de la Société d' Acclimatation*, is furnished by the Scotch pine and Norway spruce fir. The white birch is also widely diffused and abundant in that kingdom. The aspen and the alder, the elm and the lime, are also common, and attain large dimensions in some districts. The timber of the spruce and silver fir is used in the construction of houses, ships, etc.; moreover, they furnish tar, and the wood reduced to pulp is employed in the manufacture of paper. Balks and planks of these two kinds of timber are largely exported. Birch wood is chiefly consumed as fuel, supplying nearly all the coasting vessels in the Baltic. As an example of the extent of trade in this article, we may mention that no less than 25,488,678 cubic feet of birch wood, for fuel, were shipped from a single port in 1872. The wood of the aspen is used in the manufacture of matches, one of the most flourishing industries of Sweden.

THE EUROPEAN WALNUT.—It is well known that walnut trees sometimes attain prodigious size and great age. An Italian architect mentions having seen at St. Nicholas, in Lorraine, a single plank of the wood of the walnut, 25 feet wide, upon which the Emperor Frederick III. had given a sumptuous banquet. In the Baidar Valley, near Balaclava, in the Crimea, stands a walnut tree at least 1,000 years old. It yields annually, from 80,000 to 100,000 nuts, and belongs to five Tartar families, who share its produce equally.—*Gardener's Chronicle.*

MR. LEWIS' FREEZING MICROTOME.

THE cut represents an instrument, which Mr. Bevan Lewis, F.R.M.S., has described at some length in the *Journal of Anatomy.* The instrument consists of three portions: 1, an ordinary Stirling's microtome; 2, a section plate; 3, a freezing and condensing chamber. "The simplicity of the arrangement will, I trust, recommend its use amongst my fellow-workers in the department of cerebral histology. Reference to the accompanying woodcut will place the reader in possession of the plan upon which this instrument has been constructed. The section plate, *a*, is riveted by a brass arm to the microtome, *b*. The freezing compartment, *c*, consists of a cylinder, *d*, and a condensing chamber, *e*, the latter being formed of brass with a sloping



floor leading to the exit tube, which is provided with a stop-cock, *f*. The cylinder is capped with tinfoil stretched across it, and has an orifice, *d*, through which the nozzle of the spray apparatus is introduced. In using this instrument it is only necessary to bring down the cap of the cylinder from one fourth to three eighths of an inch below the level surface of the section plate, and to place in it a section of brain of about the same thickness. The spray instrument is inserted at the orifice, and by the ordinary double elastic balls a free play of ether beneath the cap freezes the tissue in from twenty to thirty seconds, or less. On withdrawing the spray instrument, the slight play of ether, still continuing from the remaining tension of the elastic ball, is utilized by being carried rapidly along the surfaces of the section blade, and then the finest possible sections may be cut with great ease. The consistence of nervous structures, when thus frozen, is really exquisite for section cutting, and the tissue remains rigidly adherent to the capped top of the cylinder. Perfect steadiness of the freezing chamber is insured by soldering it to the microtome plug, and it can be readily removed from its position by throwing back the section plate, a movement allowed for by the hinge joint, H."

SULPHUROUS CASTINGS.

THE invention of Mr. J. G. Willans, of Bayswater, England, relates to those castings which are made of steel or iron containing less than $1\frac{1}{2}$ per cent. of carbon, and has for its object the increasing the fluidity of the metal when molten, and its solidity or toughness when cold. It consists, firstly, in making these castings to contain more sulphur than carbon, or it may be to contain sulphur without any appreciable quantity of carbon. And, secondly, in making castings of steel or iron, to which a sulphuret of another metal which alloys with iron had been added, or to which the alloying metal as well as sulphur or its compounds had been added without reference to the relative proportions of carbon and sulphur in the casting. In carrying out the first part of the invention he prefers to melt down in covered clay crucibles, such as are used by steel melters, wrought iron scrap in pieces not exceeding 1 lb. in weight, grey cast iron (containing little phosphorus and about 3 per cent. of carbon), and a sulphuret of iron in the form of pyrites in the following proportions: To every 10 lbs. weight of the wrought iron scrap he adds $1\frac{1}{2}$ lb. of the cast iron, and 3 ozs. of an iron pyrites in a crushed state, containing about 48 per cent. of sulphur, or 4 ozs., if the pyrites contains only 35 per cent. of sulphur. He casts the metal when well molten into such moulds as are commonly used by steel founders. In carrying out the second part of his invention, he adds to the steel or iron from which the casting is to be made a compound of sulphur and other metal alloying with iron, such as sulphuret of copper, or of tin, or of potassium, or of manganese, or non-volatile sulphurets of other metals. Or any of these metals or substances yielding them may be added together with sulphur or its compounds, such as sulphates or sulphides. He prefers for castings of a comparatively soft kind to mix wrought iron scrap and cast iron as before, and to add to every 10 lbs. of the wrought iron $1\frac{1}{2}$ lb. of the cast iron, and 3 ozs. of crushed Spanish pyrites, containing from 1 to 3 per cent. of copper, and about 48 per cent. of sulphur, such as the pyrites now largely used by the makers of sulphuric acid. He also adds $\frac{1}{2}$ oz. of metallic tin, or instead of it 16 ozs. of tin-plate scrap.

FUEL USED TO SMELT A TON OF IRON.

As a great deal of curiosity is expressed, often by iron-masters themselves, concerning the quantity of fuel used to smelt a ton of pig iron in various localities, we have collected the following facts from the papers published in the Transactions of the American Institute of Mining Engineers, and from *The Bulletin* of the American Iron and Steel Association, believing them to possess interest for our readers.

In January, 1876, Mr. T. F. Witherbee says (Vol. 4 of the Transactions, page 880) the Cedar Point Furnace, at Port Henry, N. Y., made iron with a consumption of 1·26 tons of anthracite coal to a ton of pig iron. Mr. John A. Church says (Vol. 4, page 124) the Crown Point Furnace at Port Henry, N. Y., uses 1·64 tons of anthracite coal to a ton of pig iron; the Bay State Iron Co., at the same place, uses 1·33 tons of anthracite coal to a ton of pig iron; and the Fletcher Furnace, at Buffalo, uses 1·399 tons of anthracite and ·028 tons of coke, or 1·427 tons of the mixture, to a ton of pig iron.

Mr. Frank Firmstone says (Vol. 4, page 128) in 1871, at the Glendon Iron Works in the Lehigh Valley, Pa., an open-top furnace used 1·19 tons of anthracite coal to a ton of pig iron; in 1872 the same furnace with a small-cone top used 1·325 tons; and in 1873 the same furnace with a double-cone top, used 1·205 tons. Mr. John A. Church says (Vol. 4, page 223) the Thomas Iron Co., in the Lehigh Valley, Pa., in the last six months of 1875, used an average of 1·75 tons of anthracite coal (which, at \$3.41 a ton, cost \$5.96) to a ton of pig iron; in the five years embraced in the period from 1869 to 1873, their average consumption was 1·978 tons of anthracite coal to a ton of pig iron. Prof. B. W. Frazier (Vol. 3, page 158) gives 1·992 tons of anthracite coal as the quantity used to smelt a ton of pig iron, but he does not locate the furnace.

Mr. John A. Church says (Vol. 4, page 124) the Stewart Furnaces, in the Shenango Valley, Pennsylvania, use 1·891 tons of raw bituminous coal and ·229 tons of coke to make a ton of pig iron, a total weight of 2·12 tons.

Mr. John Alexander says (Vol. 1, page 227) the Brazil Furnace, Indiana, used, in 1872, $2\frac{1}{4}$ net tons of raw coal to gross ton of pig iron. The coal then cost from \$1.23 to \$1.75 per ton at the mine (page 230).

In a discussion on blast furnace economy (Vol. 1, page 316) it was stated that in 1872 the Fletcherville furnace in Essex County, N. Y., used 0·95 tons of charcoal to smelt a ton of pig iron. Mr. John A. Church says (Vol. 4, page 124) The Deer Lake Furnace, No. 1, in the Lake Superior region, uses 1.073 tons of charcoal to a ton of pig iron; Deer Lake Furnace, No. 2, uses 1·007 tons of charcoal; Morgan Furnace, in the same district, uses 0·853 tons of charcoal; Bay Furnace uses 0·858 tons of charcoal; Fayette Furnace uses 1·0 0 tons of charcoal; and Elk Rapids Furnace uses 0·884 tons of charcoal.

Prof. B. W. Frazier says (Vol. 3, page 158) one of the furnaces of the Clarence Iron Works, England, uses 1·125 tons of coke to a ton of pig iron, and a furnace at Pouzin, France, uses 1·2 tons of coke to a ton of pig iron.

Mr. William E. S. Baker, Secretary of the Eastern Iron-masters' Association, has published a table of the cost of the materials used in making a ton of pig iron each year from 1850 to 1875, in which he gives 2·859 tons of anthracite coal as the average consumption of fuel to a ton of pig iron at a furnace on the Susquehanna River in Pennsylvania; in 1875 the coal used to smelt a ton of pig iron cost \$7.21.

In 1875, Mr. John Fulton, then of Saxton, Pa., in the Broad Top coal field, estimated that to smelt a ton of pig iron would require 1·75 tons of Broad Top coke, 1·75 tons of Connellsville coke, or 2 tons of anthracite coal. At that time he stated the cost of each fuel at Harrisburg to be as follows: Broad Top coke, \$3.78 per ton; Connellsville coke, \$4.25 per ton; anthracite coal, \$4.50 per ton. The cost of the fuel used to smelt a ton of pig iron at Harrisburg was then as follows: Broad Top coke, \$6.61¼; Connellsville coke, \$7.43¾; anthracite coal, 9.

We print the above fragmentary facts just as we find them, and without having any theory of our own to present in connection with them. The subject of the economical use of fuel in the manufacture of iron is, however, one of such great importance that we have thought our readers would be interested in the above statement. In the course of a week or two we will present an exhaustive article upon this subject from the pen of Mr. John Fulton, mining engineer, to which we invite attention in advance.—*Bulletin.*

PROCESS OF APPLYING OXYGENATED AIR IN BLAST-FURNACES.

By CHARLES HORNBOSTEL, BROOKLYN, N. Y.

I HAVE discovered that, by bringing a current of air, under pressure, into violent contact with a mixture of sulphuric acid and black oxide of manganese, or by passing the air through or into contact with an extended surface of the same, complete decomposition of the materials can be effected without the use of heat, and at the same time the gas can be conveniently and continuously applied to metallurgical operations, and to assist the combustion of fuel in furnaces.

In carrying out my invention, I mix the sulphuric acid and black oxide of manganese in the proper proportions, which may be the same as usually employed, although for convenience I prefer to employ the manganese slightly in excess of the ordinary proportions, so as to form a thicker mass, taking care to have the black oxide of manganese as pure and free from metallic manganese as possible, in order to form no unnecessary residuum in the vessels. These materials I place in a vessel of any desired construction, into which leads a pipe from a blast apparatus, which projects downwardly toward the bottom upon which the material is placed, or enters said vessel in such manner as to force the air violently into contact with the material, or through it. From the top or other convenient part of the

vessel extends a pipe, by which the admixture of gas and air is conducted to the place of use.

Upon forcing a current of air through the induction pipe, so as to violently agitate the mass of material, or pass through it, or otherwise come into contact with every particle of the same, the decomposition will commence, and continue until thoroughly completed, without the assistance of heat, and the gas will be taken up as it is generated, and thoroughly commingled with the air, and in this condition can be effectively applied to the intended purposes.

By means of my improved process I am thus enabled to produce the gas without the aid of heat, which effects a material saving in expense, and enables me to employ, in the construction of the generating vessels, comparatively inexpensive materials, such as wood and lead, instead of the expensive glass or platinum vessels heretofore found necessary, and at the same time affords an effective means of applying the gas continuously while the charge lasts, and when exhausted, the charge may be quickly replaced and the operation continued, as before.

IMPROVEMENT IN ORE-WASHERS.

By HENRY E. TAYLOR, of Chester, Eng.

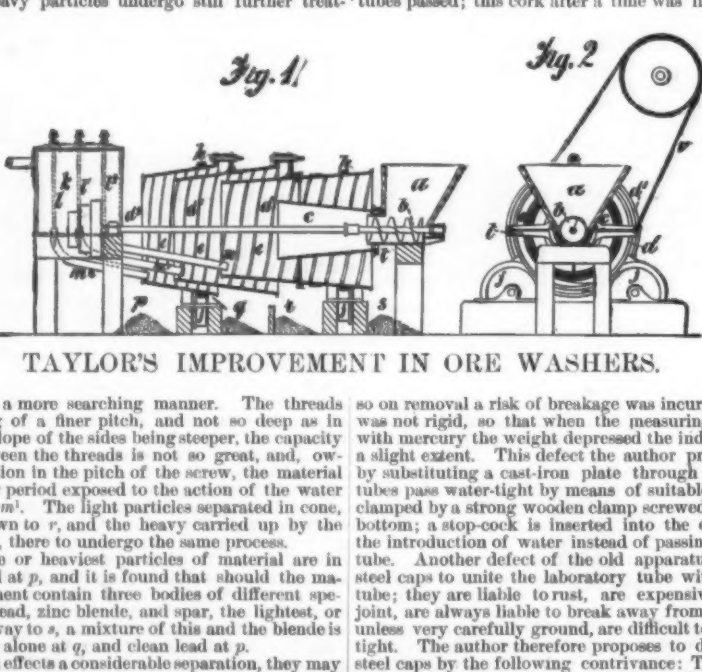
THE material is first thrown into the hopper, *a*, by an elevator or by hand. It is thence fed into the cone, *c*, by the worm, *b*, in the quantity found best by experience. When the material has reached the cone, *c*, the rotary motion imparted to it from the separating drums, along with which it is driven through the arm, *t*, traverses it to a point a little beyond the middle of the length of the first drum, *d*, into which it falls. There it meets with a stream of water issuing from the pipe, *m*. The tendency of this stream is to wash down the material over the thread or threads of the screw to the larger or lower end at *s*. The drums are, however, made to revolve in such a direction that the tendency of the threads of the screw is to carry up the particles of material held in partial suspension by the water against the stream issuing from pipe *m* to the higher or smaller end. The heavy particles, gradually settling in the space between the threads of the screw, are carried up into the next drum, *d*¹, and the lighter are washed down to *s*. After this partial separation in drum *d*, the heavy particles undergo still further treatment in *d*¹, but in a more searching manner. The threads of the screw being of a finer pitch, and not so deep as in drum *d*, and the slope of the sides being steeper, the capacity of the spaces between the threads is not so great, and, owing to the diminution in the pitch of the screw, the material is left for a longer period exposed to the action of the water issuing from pipe *m*¹. The light particles separated in cone, *d*¹, are washed down to *r*, and the heavy carried up by the screw thread to *d*², there to undergo the same process.

The finished ore or heaviest particles of material are in this way deposited at *p*, and it is found that should the material under treatment contain three bodies of different specific gravities, as lead, zinc blende, and spar, the lightest, or spar, is washed away to *s*, a mixture of this and the blende is found at *r*, blende alone at *q*, and clean lead at *p*.

Since each drum effects a considerable separation, they may be employed singly, or in any number to suit the material under treatment.

When the machine is used for sizing, the smaller particles are washed out, and deposited at *s*, the next at *r*, and so on.

By increasing or diminishing the distance between the rollers, *j j*, either extremity of the apparatus can be elevated or depressed, so as to alter the speed of flow of the fluid over the material. The pitch of the screw threads may be altered to produce the same effect.



TAYLOR'S IMPROVEMENT IN ORE WASHERS.

CHEMICAL SOCIETY, LONDON, JUNE 7, 1877.

On the Gases enclosed in Lignite Coal and Mineral Resin, from Bovey Heathfield, Devonshire," by J. W. Thomas. Four samples were examined. No. 1 Lignite consisted of the leaves and atoms of plants in a closely compressed condition, and is known locally as "leafy coal." No. 2 Lignite—dense, compact, of a distinctly woody character and dark brown. No. 3 Lignite was very dense, but earthy and wet in appearance, the cleavages being much encrusted with hydrated oxide of iron; in color it was nearly black. No. 4, Mineral Resin Retinasphaltum—soft, brown, powdery, lighter than water.

No. 1. Leafy coal from Bovey Heathfield.—100 grms., after heating to 50° for twelve days gave 56·1 c.c. of gas, containing—CO_2, 87·25; O, 0·24; CO, 3·59; OH_2, 8·92 per cent. After heating to 50° 100 grms. were heated to 100° for eighteen days, and yielded—59·9 c.c. of gas; CO_2, 89·53; C_nH_{2n} gases, 0·33; CO, 5·11, N, 5·03 per cent. On raising the temperature to 150° decomposition set in, and the pellets of mercury in the Sprengel became blackened by the formation of sulphide of mercury. The gas given off had at first an aromatic odor, but afterwards became exceedingly disagreeable from the presence of organo-sulphur bodies, mercaptan, sulphide of allyl, etc. At 200° more than 18 c.c. of gas were collected, the last portions of which contained CO_2, 82·06; H_2, 2·82; CO, 14·00; C_2H_4, 0·49; C_2H_6, 0·48; N, 0·27 per cent. Above 250° it was impossible to collect any gas, the action of the sulphur compounds on the mercury being so energetic as to block the Sprengel.

No. 2 Lignite—100 grms. at 50° evolved 48·5 c.c. of gas, consisting of—CO_2, 96·23; O, 0·11; CO, 2·42; C_nH_{2n} gases, a trace; nitrogen, 1·24 (the first portion of gas which came off contained 16·23 per cent N). At 100° sulphur sublimed in small yellow crystals; the lignite began to decompose at 185°. At 200° the gas consisted of CO_2, 86·30; CO, 7·41; C_nH_{2n} gas, 27·08; marsh gases, 3·34; hydride of propyl, 0·53; nitrogen, 0·34 per cent.

No. 3 Lignite began to decompose at 180°; the gas evolved at 200° consisted of SH_2, 0·41; CO_2, 91·68; C_nH_{2n}, 0·41; CO, 7·12: H, traces; N, 0·38 per cent.

No. 4. Mineral Resin from Bovey Heathfield.—At 50° a very small quantity of gas was given off. At 100°, 21·4 c.c. of gas from 100 grms. came over; CO_2, 88·24; O, 0·23; C_nH_{2n}, 0·47; CO, 7·90; N, 3·16 per cent. At 110° to 120° it began to melt and decompose, the sulphur compounds coming off so rapidly as to block the pump. When the temperature was raised to 160°, about 180 c.c. came over, consisting of SH_2, 0·41; CO_2, 78·88; C_nH_{2n} gases, 2·67; CO, 7·82; marsh gas, 8·05; hydride of propyl, 1·86; nitrogen, 0·31. When compared with the coals of the carboniferous period, it is seen that, as far as the occluded gas is concerned, these lignites resemble most cannel coal but contain C_nH_{2n} gases, and only matters of the aromatic series instead of gases and compounds of the paraffin series. The lignites are far less stable *in vacuo*, decomposing below 200°, while the true coals usually resist a temperature of 300°. The existence in Nos. 1 and 3 of organo-sulphur compounds in the presence of hydrated oxide of iron suggests that the iron pyrites of true coal may have derived their sulphur from that existing in organic combination in the plants from which coal is produced, and not from the reduction of sulphates. The author concluded by pointing out the extremely hygroscopic nature of the Bovey lignites. Mr. Thomas also exhibited two mechanical appliances driven by water or steam for shaking a beaker containing a precipitate so as to promote its settling or for hastening the solution of a substance. He mentioned that with the aid of the apparatus the magnesia precipitate came down from a dilute solution in fifteen to twenty minutes.

"Apparatus for Gas Analysis." By DR. FRANKLAND. After giving a short description of the original apparatus introduced by himself and the late Mr. Ward, the author proceeded to point out the various modifications the apparatus had met with at the hands of Mr. Duppa and Professor McLeod. Notwithstanding all improvements there were still some disadvantages connected with the apparatus. In the first place the bottom of the water cylinder was closed by an india rubber cork, through which the two tubes passed; this cork after a time was liable to stick, and so on removal a risk of breakage was incurred; moreover, it was not rigid, so that when the measuring tube was filled with mercury the weight depressed the india rubber cork to a slight extent. This defect the author proposes to remedy by substituting a cast-iron plate through which the glass tubes pass water-tight by means of suitable collars, and are clamped by a strong wooden clamp screwed to the cast-iron bottom; a stop-cock is inserted into the cast-iron base for the introduction of water instead of passing it down a glass tube. Another defect of the old apparatus was the use of steel caps to unite the laboratory tube with the measuring tube; they are liable to rust, are expensive, form a rigid joint, are always liable to break away from the cement, and unless very carefully ground, are difficult to make absolutely tight. The author therefore proposes to do away with the steel caps by the following contrivance: The upper end of the measuring tube terminates in a small cup like a small funnel with a very acute angle. The tube from the laboratory tube is bent twice at right angles, and then drawn out at its end so as to go into the neck of the above cup (without grinding). It is then covered with a piece of thin sheet unvulcanized india rubber, the edges of which are cut off, warmed, and joined so that a conical stopper of india rubber is formed: this, when moistened and pressed down into the cup by an india rubber band and covered with mercury, forms a perfectly airtight joint which is nevertheless flexible.

Mr. Warrington said the joint had been most severely tried, not only with regard to its tightness, but as regards the possibility of any air space being left between the capillary tube and the cup, but no perceptible error could be detected.

Dr. Frankland said there was another point he had forgotten to mention, the rack and pinion of Regnault's apparatus was replaced by a long screw, the shelf for the mercury trough sliding on a V-shaped guide, and having a nut to fit the screw. In answer to Dr. Wright, who asked if the india rubber cone was greased or not to secure the tightness of the joint, Dr. Frankland said that the joint was only moistened with water.

Dr. Russell bore testimony to the necessity of wetting india rubber and glass joints to secure their tightness. With regard to the improvements brought forward by Dr. Frankland, he would say only those who have worked with the old apparatus could properly appreciate them.

Mr. Greenway pointed out the great ease with which the tube could be cleared by reagents now that the steel caps had been got rid of.

DR. WRIGHT then read a paper on "*Narcotin, Cotarnin, and Hydrocotarnin,*" Part V. A large number of experiments made with a view of breaking up cotarnin into simple bodies, and so to elucidate its structure, were as fruitless as were attempts made to synthesize narcotin from mixtures of hydrocotarnin and opianic acid. By adding on hydrocotarnin hydrobromide with bromine the following actions take place:

$$1.\quad C_{12}H_{15}NO_3,\ HBr + Br_2 = \underbrace{HBr + C_{12}H_{14}BrNO_3,\ HBr.}_{\text{Bromhydrocotarnin hydrobromide.}}$$

$$2.\quad C_{12}H_{14}BrNO_3,\ HBr + Br_2 = \underbrace{2HBr\ \ C_{12}H_{12}BrNO_3,\ HBr.}_{\text{Bromocotarnin hydrobromide.}}$$

$$3.\quad C_{12}H_{12}BrNO^3,\ HBr + Br_2 \underbrace{= C_{12}H_{12}Br_2NO_3,\ HBr.}_{\text{Tribromhydrocotarnin hydrobromide.}}$$

The formation of the first two bodies is preceded by the production of the unstable addition products

$$C_{12}H_{15}Br_2NO_3HBr \text{ and } C_{12},$$

and $C_{12}H_{14}Br_3NO_3HBr$ respectively: the third addition product, tribromhydrocotarnin hydrobromide, is a well defined crystalline stable substance. Bromhydrocotarnin and bromocotarnin resemble in general principles hydrocotarnin and cotarnin respectively. The first crystallizes anhydrous, and melts at 76°. The second is

$$C_{12}H_{12}BrNO_3,H_2O,$$

and loses water at 100° with decomposition; their hydrobromides crystallize well, that of the first being sparingly soluble in H_2O and anhydrous, while that of the second is easily soluble, and contains $C_{12}H_{12}BrNO_3HBr,H_2O$. When heated to about 200° bromocotarnin hydrobromide fuses, gives off HBr and combustible vapors (apparently CH_3Br), and forms a small quantity of the hydrobromide of a new base termed "tarconin" (anagram on cotarnin and narcotin) $C_{11}H_9NO_3$, and a large amount of an indigo-blue substance, the hydrobromide of a base $C_{20}H_{14}N_2O_6$; this base and its salts are all but insoluble in water, ether, alcohol, benzene, CS_2, petroleum, etc.; boiling aniline and glacial acetic acid dissolve a minute quantity, forming a deep blue fluid; strong H_2SO_4 dissolves it, forming a sulphate $(C_{20}H_{14}N_2O_6)2H_2SO_4$. The solution has a tint rivaling magenta in beauty and intense coloring power. Tribromhydrocotarnin hydrobromide fuses at 200°, and decomposes in accordance with the reaction—

$$C_{12}H_{12}Br_3NO_3,\ HBr = HBr + CH_3Br + C_{11}H_8BrNO_3,\ HBr,$$

forming bromotarconin hydrobromide. Bromotarconin forms fine scarlet crystals, $C_{12}H_8BrNO_32H_2O$, which become crimson when dried at 100°. The crimson anhydrous mass, when dissolved in hot absolute alcohol, perfectly free from water, separates on cooling in crimson crystals, but if the least trace of moisture be present, the scarlet hydrated crystals appear. The salts are pale yellow, well crystallized and sparingly soluble in cold water. The hydrochloride and hydrobromide contain $2H_2O$. Cotarnin hydrobromide is very soluble—

$$C_{12}H_{13}NO_3HBr_2H_2O;$$

with bromine it forms the addition compound dibromhydrocotarnin hydromide, $C_{12}H_{13}Br_2NO_3HBr$, which, by further action of Br produces tribromhydrocotarnin hydrobromide, identical with that from hydrocotarnin. By the action of water dibromhydrocotarnin hydrobromide splits up into HBr and bromocotarnin hydrobromide. By the action of zinc and hydrochloric acid bromocotarnin takes up H_2 and forms bromhydrocotarnin identical with that obtained by brominating hydrocotarnin By acting on opianic acid with a large excess of HI almost the theoretical yield of CH_3I is obtained for the reaction—

$$C_{10}H_{10}O_5 + 2HI = 2CH_3I + C_8H_6O_5$$

(noropianic acid). The noropianic acid thus produced crystallizes with $2H_2O$, and is not identical with the body recently described by Tiemann as isonoropianic acid.

"*Otto of Limes,*" by C. H. PIESSE and DR. WRIGHT. The otto from the rind of the fruit of the *Citrus limetta* had a sp. gr. of 0·90516 at 15·5° C. When distilled about two-thirds passed over below 186°. After purification by fractional distillation and finally over sodium this yielded a terpene body boiling at 176°. On treating with bromine an unstable dibromide was formed, unlike the dibromide of the hydrocarbon from orange peel (hesperidene). This yielded but little cymene by simple heating, the greater portion being transformed into resinous non-volatile bodies. The cymene thus produced boiled at 176°, and yielded terephthalic and acetic acids by oxidation with chromic acid; hence it would seem that the terpene of the lime is not identical with that of the orange, notwithstanding the nearness of their boiling points, but that it is more like the terpene of the lemon (boils about 173°), which, as Openheim has shown, yields a dibromide from which but small quantities of cymene are formed by simple heating. The residue not volatile at 186° was further heated, and gave a few drops of distillate between 186° and 250°. The residue in the retort was a semi-solid resin. On standing two or three months a quantity of crystals formed in the soft mass. These were extracted by the pump fitter, well washed with the terpene and with alcohol, and crystallized successively from strong and dilute alcohol. They formed white miraceous plates, scentless, neutral, not volatile without charring, giving numbers agreeing with the formula $C_{24}A_{22}O_5$, melting at 162°, not forming protocatechuic acid on fusing with potash, and therefore not identical or even allied to hesperidin.

Mr. Grosjean pointed out that in Sicily the otto was collected by powerfully squeezing the rind of the lime against a clean sponge. He objected to the formation of new names for chemical substances by the anagrammatic method.

"*Primary Normal Heptyl Alcohol and some of its Derivatives.*" By MR. C. T. CROSS. Pure œnanthol was prepared by a rapid dry distillation of castor oil and fractional distillation. Its sp. gr. was 0·823 at 16° C.; at 748·6 m.m. it boiled at 152°. Heptyl alcohol was prepared by acting on 15 grms. of œnanthol dissolved in 150 grms. of 65 per cent. acetic acid with 10 grms of sodium in 1,000 grms. of mercury for ten days; the alcohol was drawn off, washed, etc., and purified by fractional distillation. From 300 grms. of impure aldehyd 120 grms. of pure alcohol, boiling 170° to 180°, were obtained. Some of the alcohol was specially purified by rectification over metallic sodium. It is colorless, has an agreeable pear-like odor; sp. gr. at 0° 0·833, at 16° 0·830, at 27° 0·824, at 764·1 m.m. it boiled at 175·5°. The following substances were also prepared,

	Sp. Gr. at 16°.				
Heptyl chloride........	0·881,	boils	754·0 m.m.	at	159·20 °
" bromide........	1·132,	"	750·6	"	178·500°
" iodide...........	1·346,	"	754·8	"	201·000°
" acetate	0·874,	"	758·5	"	191·500°
" œnanthylale ...	0·870,	"	760·0	"	370·272°
" ethylether......	0·790,	"	748·3	"	165·000°

In conclusion the author draws attention to the coincidence of the boiling points of the above compounds with those calculated by Schorlemmer, viz., chloride 158, bromide 170, iodide 200, acetate 191·5.

SALTS OF THE SESQUIOXIDE OF CHROME.—M. A. Etard. The only crystalline sulphate of chrome hitherto known is the violet sulphate to which Schrœtter gives the formula $Cr_2(SO_4)_3 15H_2O$. This formula—differing by three molecules of water at least from the sulphate of alumina, $Al_2(SO_4)_3$, $18H_2O$—may seem exceptional if we take into account the analogies and the isomorphism which generally prevail be-

tween the salts formed by the sesquisalts of chrome and alumina. Without denying the possible existence of a salt with 1 H_2O which may be obtained by other methods, the author has sought for a sulphate with $18H_2O$, which he regards as normal, and finds that it may be easily prepared by allowing the vapors of ether to react upon a solution of 100 parts CrO_3 in 150 parts of sulphuric acid and 225 of water. The chromic sulphate thus obtained is a fine violet salt, permanent in the air, and of a well defined composition. If dried in the open air its composition is $Cr_2(SO_4)_3 18H_2O$. At 100° it loses 30 5 per cent. of its weight, and, parting with $12H_2O$, it is converted into the green crystalline sulphate $Cr_2(SO_4)_3 6H_2O$. This latter salt, which is deliquescent, loses its six molecules of water at dull redness, and becomes the anhydrous sulphate, $Cr_2(SO_4)_3$. Hence the violet sulphate may be formulated as:

$$[Cr_2(SO_4)_3 6H_2O]\ 12Aq$$

From the comparison of these formulæ it would seem that the difference between these two varieties is the result of a super-hydration of the violet salt. Along with chrome alum, regarded in its anhydrous state as $Cr_2(SO_4)_4K_2$, may be ranked a crystalline and well defined salt of the formula $Cr_2(SO_4)_6K_6$, or in equivalents $Cr_2O_3 3SO_3, 3KO, SO_3$. This salt, which is very stable, represents a molecule of anhydrous sesquichloride of chrome, Cr_2Cl_6, in which the chlorine is replaced by residues of bisulphate of potassa, $Cr_2(SO_4K)_6$. The bisulphate of potassa acting as a true monabasic acid, the author proposes to call this new double salt potassio-sulphate of chrome. It is easily obtained by putting small portions of the anhydrous chloride, Cr_2Cl_6, into melted bisulphate of potash, and heating to redness for a few minutes. A sodio-sulphate of chrome and a potassic-sulphate of iron may be obtained in an analogous manner. In these salts the relations between the acid of the sesqui-sulphate and that of the alkaline salt are the same, exactly as in the series of double salts known as Magnesian; $Cr_2(SO_4)_3, 3SO_4 K_2$, potassio sulphate; $(MgSO_4)_3, 3SO_4K_2$ (triple magnesian sulphate).—*Comptes Rendus.*

HOW STEAM INCREASES ITS OWN HEAT.

STEAM at ordinary pressure sent into saline solutions on which it has no chemical action, gives a rise of temperature that seems at first sight paradoxical, the temperature produced being always higher than that of the steam. M. Muller, of the Berlin Chemical Society, has been studying the phenomenon. Chloride of sodium is one of the best salts to use. A solution of it sufficiently concentrated to have a boiling point of 127° may be raised to 125° simply by sending steam into it at 100°. Here, then, the steam produces a rise of 25° above its own temperature. The more concentrated the solution the higher is the rise. M. Muller points out, in explanation, that saline solutions at 100° absorb the steam at the same temperature, and the result is a rise analogous to that produced when a gas, like ammonia, is dissolved in water. These experiments throw new light on the controverted question, what is the temperature of the steam which escapes from a concentrated and boiling solution? Is it 100° or a temperature near that of boiling of the solution? The new results seem to be against the latter, and common, view.

[PHOTOGRAPHIC TIMES.]

CHEMICAL AND PHOTO. NOTES.

To Remove Silver Stains from Clothing.—This process is especially successful in removing spots from materials which have been several times washed. First prepare a saturated solution of chloride of copper, dip the spotted piece in the solution, and allow it to remain some minutes, according to the character of the stain. Then rub the part with a crystal of hyposulphite of soda. When neutral chloride of copper is used the color of the stuff does not change. This process can be repeated.

Prevention of Blisters on Albumen Paper.—Henvess & Weise, at Wernigerode, recommend as an absolutely reliable and very effective remedy against blisters on albumen paper an alcohol bath, in which the pictures are allowed to remain, after the gold bath, until they have a glassy appearance; the time required is from two to three minutes. They are then dipped into water, and treated in the usual manner. This alcohol bath can be used about twelve to fourteen days, and may be used in lamps for burning purposes; thus the cost is reduced materially.

To Remove Iron Spots from Clothing or other materials.—This question was answered as follows by Mr. Grüne, in the session of the Society for the Promotion of Photography.

The spots are colored blue with yellow prussiate of potash; wash with caustic soda, treat it with oxalic acid, afterwards washing well with water. Treated directly with oxalic acid, only fresh spots disappear.

Silvering of Glass.—(By Prof. Dr. Himly.)—Dissolve separately in definite proportions of distilled water, seven teen parts of nitrate of silver and twenty-eight parts of potash and soda (the so-called Rochelle salt); mix the solutions. There is a precipitate of cheesy-looking tartrate of silver, which crystallizes in a few minutes; after settling the liquid is to be poured off and replaced three or four times by distilled water (shaking well each time), until the precipitate is thoroughly washed; add a small portion of distilled water, and cork the bottle well, setting it aside for use whenever required. Better kept in a dark place. When used the vial must be thoroughly shaken; a portion poured into a corked bottle; to this add strong ammonia, shaking all the while. To insure success the proportions of ammonia must be accurately observed. Should it be in excess, add small proportions of the silver salt until there is always a small amount of the salt undissolved. In a few moments the commencement of the silvering process can be noticed on the inside of the glass itself, which can be slackened by adding a greater amount of distilled water to the fluid, according to the surface of glass to be silvered. The surplus of the silver salt, which turns black, settles at once to the bottom, after which the clear liquid is to be distributed over the surface of the glass. It acts at once, and in twenty minutes the glass is coated with a fine surface of silver.—*Poggendorff's Annalen.*

Taking Impressions of Negatives.—In Braun's establishment (at Dornach) impressions of negatives are taken and kept between sheets of paper, mainly for the purpose of use in an inverted manner. This is often necessary for licht-druck, and is also convenient for pigment prints, because good pictures are produced by simply transferring.

Impressions are taken in the following manner:

Clean the glass plate thoroughly, rub it over with stone alum. In no case have it albumenized, or an under coating to make it adhere more firmly. The negative is put on in the usual manner. After fixing and washing allow it to become half dry; pour upon it the following mixture: Gelatin, 100 parts; water, 400 parts, 10 to 15 parts glycerin, and 1 0 parts alcohol. In warm weather the plate dries in a few hours. When dried pour upon it one and a half per cent. plain collodion; dry again, and make a cut in the coating around the picture; it then detaches easily, or comes off itself.

In the copying-frame a greater pressure is necessary for these films than for glass negatives; Braun is using, therefore, layers of vulcanized caoutchouc, about the thickness of a finger.—*Photgr. Mittheil.*

Washing of Photographic Silver Pictures in Zinc Vessels.—(By F. W. Geldmacher).—It almost invariably happens that in new zinc vessels the pictures receive gray spots, which are nearly the same color as the zinc itself, and have the appearance of grease-spots, especially when the light shines through them. It is only those copies which come directly in contact with the metal which show these spots; those floating in the water, without touching, are not affected. The decomposing effect of metallic zinc upon the copies, which still contain chloride of silver dissolved in hyposulphite of soda, is only seen where it comes in direct contact.

Copies which are entirely free of soda may be washed in such vessels with impunity, showing no spots at all. These spots frequently disappear after drying; occasionally, however, they remain, and the pictures are spoiled.

This can be prevented in two ways:

1st. By washing the copies in a vessel made of some metal substance, before placing them in the zinc vessel.

2d. By placing in the bottom a piece of paper, or oil cloth, so as to prevent the copies from touching the vessel.

When the surface of the zinc has become porous and roughened, and the metallic lustre has disappeared, these measures are no longer necessary, because these gray spots no longer appear.

For very large pictures (such as 2 1, 4-1 sheet and more) the use of zinc vessels is necessary, because those made of other materials are easily broken.

Large zinc vessels should be surrounded by wood which is covered with asphaltum or shellac, in order to prevent warping.

A new Gold Salt for Photography.—(By Dr. J. Schnauss).—Until now there have been used only the single and double chloric salts of gold for toning. During the past winter Mr. Neumayer, student of chemistry from Munich, visited my establishment and undertook under my directions the preparation of a gold bromide and a gold bromide of calcium, for the purposes of experimenting with these salts and their uses in photography.

Thin leaves of gold are readily dissolved in bromine water and in bromine gas. But a more rational and less disagreeable mode of preparation is by the action of hydrobromic acid, nitric acid, and aqua regia.

During the evaporation of the gold bromide, which has a dark appearance and smells strongly of bromine, great care is necessary owing to the fact that the gold bromide vapor izes easier than the chloride. Bromide of gold is difficult to crystallize. By the addition of an exact equivalent of bromide of calcium dissolved in water, and evaporated, small granite red crystals of double salts are obtained. $KBr + AuBr_3 + 5H_2O$ can be with difficulty dissolved in water; but a thin solution is of a deep red color, and effloresces in dry air.

I have tried these double salts, also the gold bromide, with several additions, as a toning bath. In its general effects on silver copies it is analogous to gold chloride combinations, except that in the same proportions it acts more energetically.

The addition of soda bicarbonate gives a blue-black tone, melted acetate of sodium a purple-colored tone.

For a lasting gold bath, in form of a *sel encause*, these salts are recommended.

We make the following extracts from Dr. Phipson's correspondence in the *Moniteur de la Photographie.*

A silver bath, not liable to deterioration, is certainly a photographic desideratum, and, at a risk of being taxed with making an exaggerated assertion, I give the formula of a bath, the author of which, an esteemed London photographer, assures us that he has used for a long time without being obliged either to filter or discolor; and, to maintain its strength, it is only necessary to add from time to time a few small crystals of nitrate of silver and an equal quantity of crystals of nitrate of soda.

Here is the formula of the silver bath in question:

Nitrate of Silver,...	2.50	grammes	(38 grains).
Nitrate of Soda, ...	1.25	"	(19 ").
Ammonia,........................			2 drops.
Wood Spirit, ...	7½	cent. cubes	(2 fl. drachms).
Water,............	30	"	(8 ").

The paper is floated on this bath for three or four minutes. As soon as the operation is finished, the bath is poured into a bottle, which is then corked.

The dry coffee process, of which Col. Baratti was one of the oldest advocates, is still considered one of the best of the published processes. The late Mr. De Constant often used it with the greatest success; and recently a correspondent in Switzerland has sent to the *Photographic News* some excellent results. Moreover, Mr. Haatmann, President of the Photographic Society of Amsterdam, and Mr. Victor Angerer, a well-known photographer in Vienna, are unanimous in declaring the efficacy of the process in question. Mr. Haatmann, who is an amateur photographer, has a great predilection for dry plates. He has tried tannin, tea, tobacco, morphia, and in general all the substances recommended, but nothing appears to him so clean and satisfactory as the coating of coffee. The plates are prepared, moreover, in the most simple manner. The solution of coffee is made thus:

Boiling Water, ...	100 c.c.	(3¼ fl. ozs.)
Pure Java Coffee (roasted),........	5 grammes.	(77 grains.)
White Sugar dissolved in a little water........	2.50 "	(33 grains.)

This infusion, after cooling, is poured on the sensitized collodion coating, and the coating is then allowed to dry

*Chloride of Palladium Process.**—Mr. Dubois Chaplain has communicated to us the following letter, which will be read with interest:

DEAR SIR: I have made use of chloride of palladium instead of chloride of gold to strengthen transparencies after fixing.

It is necessary to eliminate with great care every trace of the fixing and developing liquids, which would precipitate the palladium either as a metal or a sulphate, and in that case the entire solution would be lost.

The great advantage of the use of the chloride of palladium is that, differently from what takes place with the chloride of gold, it may remain upon the pellicle as long as is desirable, without fear of injuring the half tones; on the contrary, it acts as a *redeveloper*, strengthening the image and imparting to it a rich black tone.

The use of chloride of palladium was first made known in the *British Journal of Photography*, but I have forgotten by whom.

The solution is composed of one part of chloride of palladium dissolved in twenty parts of distilled water.

Your price of one franc and a half a gramme (28 cents for 15 grains) is considerably less than what I have paid here, and will certainly induce operators to make use of the salt.

ELLERBECK.

INSTANTANEOUS PHOTOGRAPHY.

A SERIES of articles have recently appeared in the *Bulletin de la Société Française*, from the pen of M. Sahler, on the above subject. M. Sahler seems to have made a profound study, both theoretically and practically, of the subject he has taken up, and we now place before our readers, by way of summary, the formulæ recommended by that gentleman to secure pictures with rapid exposures.

Accelerating Liquid.—Into a bottle capable of holding one tenth of a litre are put sixty cub. cents. of alcohol and one gramme of iodide of cadmium; then drop by drop is added sufficient ammonia until the last drop brings about the slightest turbidity. The clear liquid is poured off, eight cub. cents. of rectified alcohol are added, together with five drops of a saturated solution of nitrate of ammonia, and the liquid is then stirred, while drop by drop so much glacial acetic acid is put in to render the liquid clear again, only leaving at the bottom of the vessel a small precipitate of hydrate of cadmium.

Collodion.—Five grammes of collodion pyroxylin are weighed; this is put into a wide-mouthed bottle and well corked, where it remains a month. The pyroxylin then begins to decompose and gives off acid vapors, and as soon as these are apparent by the smell, the product may be employed.

A litre bottle is taken, and into it are poured three hundred cub. cents. of alcohol; in this are dissolved nine grammes of iodide of cadmium, and then the five grammes of decomposed pyroxylin, together with another five of undecomposed cotton, are added. Stirring the while, there is added by degrees ether (of 62°) enough to dissolve the pyroxylin. Finally, the bottle is filled with a mixture of alcohol and ether.

The collodion is tested by pouring some of it upon a glass plate. If the film is not stout enough, little pyroxylin is added; if it is ropy, more alcohol should be added. Then, in the open air (to prevent one breathing the injurious fumes), thirty drops of bromine are permitted to fall into the bottle.

The decomposition products of pyroxylin oxidize the alcohol and change it into aldehyde; the iodine displaced by the bromine combines with the nitrogenous oxides, when a similar noise will be heard to that made by a hot iron being thrust into water. Iodate of chromium is formed, which subsequently combines with ammonia.

The accelerating liquid is shaken up, allowed to remain for five minutes, so that any coarse particles may sink to the bottom, and then three-fourths of the contents of the bottle is poured into the collodion. If the latter becomes turbid, it is filtered, and then two drops of ammonia are added.

If the collodion does not become colorless within ten days, then one or two drops of ammonia are added. It does not matter if it is a little turbid. It is put into long narrow bottles and permitted to stand until it is clear. It should be of a light-yellow color; if colorless, it is tinted before use every time with a few drops of tincture of iodine. It will keep good a very long time.

If the pyroxylin has been too much decomposed, the collodion will not adhere to the glass; a little ordinary iodized collodion is then added to it. When the collodion grows very old, its sensitiveness may by materially increased by the addition of one or two drops of the undermentioned reducing fluid. In fifty grammes of alcohol are poured six drops of aldehyde and three drops of ammonia. This solution must remain some days before it is used. Still more sensitive becomes the collodion by the addition of one or two drops of an extra accelerating fluid, composed as follows: Into fifty grammes of alcohol are put eight drops of aldehyde and three decigrammes of caustic potash; after standing a fortnight the fluid becomes of a dark-brown color and ready for use. The collodion is allowed to remain for some hours; before use the upper portion is poured off.

The so-called Mann pyroxylin does not yield any acid fumes on keeping When this is mixed, there should be added, before the iodide of cadmium is employed, eight drops of the extra-accelerating fluid to the alcohol, and no ammonia afterwards.

Dry Collodion.—The collodion above described requires no covering or preservative. Its sensitiveness is improved by a solution of fifteen centigrammes of resin for every hundred cub. centimetres of collodion. The maximum sensitiveness of this collodion is, however, reached by employing with it a solution of tannin.

PHOTO-LITHOGRAPHIC PAPER.

By PROFESSOR J. HUSNIC, at Prague.

THE ordinary photo-lithographic paper, which is used for reproducing pictures in line or stipple, is prepared either from albumen or gelatin.

Each variety requires separate treatment, and each has its advantages and disadvantages. Owing to the latter, they are seldom used in practical printing, being confined principally to experimental work.

These papers are sensitized with chrome salts, exposed under a negative; then blackened with a fat paint thinned turpentine, and after drying placed in water. The paper will be thoroughly soaked by the water, and the paint with the coating (when consisting of albumen) can be removed from the unsensitized plates by means of a sponge, or the coating when of gelatin) will remain upon the paper; the paint alone can be removed by rubbing. The chief advan-

* From the *Moniteur de la Photographie.*

tage of the albumen method consists in the ease and rapidity with which the picture is developed. Its disadvantage being, however, that the preparation of the albumen paper requires much time and trouble, and that only a few sheets can be prepared at a time, about enough for each day's use.

The white of eggs should be beaten until it resembles snow; allow it to stand awhile, and add the chrome salts. Frequently it happens that we have to throw away the solutions after the preparation of a few sheets, because neither the paper nor solution will adhere. There is another disadvantage which this method possesses, namely, that in developing the picture the surface of the soaked paper is easily rubbed off, thus spoiling the picture.

The gelatin papers can be prepared in great quantities, because the gelatin may be applied separately, and the prepared sheets can be sensitized in the chrome salt bath, which is capable of holding itself. This advantage of the gelatin process is greatly counteracted by the fact that the papers allow of no rapid and easy development of the picture, requiring several kinds of skilled treatment, especially the use of a paint roller to remove the superfluous paint. Whenever excellent results are produced, it is only by very skillful treatment. Whoever has tried to roll out a sheet of paper will appreciate this difficulty. In fact, skillful hands are requisite to discover the places where the color is to be removed or the shades require to be more or less opened. The development must be quickly accomplished, and only by means of a sponge. This is a simple process, and should enable amateurs, even when they understand nothing of drawing, to execute the operation skillfully.

Sometimes the picture is spoiled by an oily tone of the whites, which is hard to remove.

The photo-lithographic paper which I prepare embodies all the advantages and none of the disadvantages of these processes. There is nothing necessary but a constant chrome salt bath, which when required is to be carefully poured from the bottle without filtration, in which may be immersed the number of sheets required for each day's use, or the operation may be repeated several times in the day, as the drying of the paper requires only one and a half hours. The development of the picture is a fast and sure process, and the stroke and graining manner appears excellently. The reprinting is sure; the papers are not crushed, and there is no tone shown in the whites.

The advantages of this paper are security to work, especially such as those fine maps, reduced to one-third, which are executed by the Imperial Printing Office for the technical military committee and the topographical department of another imperial establishment at Vienna.—*Photogr. Notizen.*

PRIZES OFFERED BY THE VIENNA PHOTOGRAPHIC SOCIETY.

THE Vienna Photographic Society offers the following prizes for the solution of various problems connected with photography:

a. VOIGTLANDER MEDALS.

1. A gold medal worth 140 ducats for a method of increasing the sensitiveness of wet plates.
2. A gold medal worth 140 ducats for a certain and rapid dry process of superior excellence.
3. A gold medal of 40 ducats for a thorough research into the asphalts.
4. A silver medal for a collection of natural history studies.
5. A silver medal for a collection of instantaneous pictures.
6. A silver medal for a collection of lantern transparencies, for illustrating science, art, or technical matters.
7. Medals in gold (of a value from 40 to 100 ducats), silver, and bronze, for scientific research, inventions, or improvements which are communicated to the society or to its organs.

b. SOCIETY MEDALS.

1. Gold medal of 140 ducats for the production of type blocks having half-tones.
2. A gold medal of 140 ducats for a critical study of the reactions of chrome acids and their salts upon albuminates, albuminoids, carbon hydrates, and resins, with particular reference to the different heliographic processes.
3. A silver medal for *genre* pictures.
4. A silver medal for carbon prints produced in Austro-Hungary.
5. A silver medal for a collection of monuments.
6. A silver medal for a collection of ethnological studies.
7. A silver medal for a collection of anthropological studies.

Competitors must qualify by becoming members of the society. Further particulars may be obtained by addressing the President, Dr. Hornig, Vienna III, Hauptstrasse 9

MOUNTING PHOTOGRAPHS.

By WALTER B. WOODBURY.

MOST amateurs, when mounting their photographs—say of the favorite cabinet form—have no doubt, been astonished to find that, although all the pictures had been cut with the same shape, leaving perhaps a margin of one-eighth of an inch at the top and sides, some of the prints nearly covered up the card in the length, while others had the opposite fault.

The subject of expansion of the paper in one direction has lately been brought forward, as tending to give two different ideas of the same portrait; but the slight difference can hardly be perceptible except to a very critical observer.

When it is a question of mounting a number of photographs to a shade within a line, then the matter becomes serious, and it is an absolute necessity to have two different shapes, one for those prints cut across the paper and the other for those cut lengthwise. The former will have to be (for cabinet size) nearly one-sixteenth of an inch shorter, and the latter one-sixteenth longer.

It is best to mark the paper cut across the sheet before printing, so as to know which shape to use; but, in case this has been neglected, the two classes of prints may be easily separated by slightly warming them, the cross prints forming themselves into a short roll, and the others into a long one. They can then each be cut with their own shape, and when mounted will be found to occupy the same position on the mount.

In using an alcoholic solution of glue, where very little water is present, the stretching of the paper is reduced to its minimum. This is best made as follows: Soak common gelatin (glue will answer) in as little water as will just dissolve it. While hot pour in gradually methylated spirit, stirring all the time until the spirit is in about the proportion of three to one of the gelatinous solutions. A species of precipitation takes place, which, however, redissolves on well stirring. A little glycerin or sugar can then be added.

Great care is necessary in mounting with this material, as if once the print is laid on the mount it is almost impossible to remove it.—*Br. Jour.*

HOW TO ENLARGE AND PHOTOGRAPH MICROSCOPIC OBJECTS.

By M. A. RUTOT.*

VERY few have till now occupied themselves with micro-photography, notwithstanding the magnificent results which microscopists have obtained, and the obvious utility of productions of this kind. This abstention is due either to ignorance of photographic manipulations, or to an exaggerated fear of the difficulties which present themselves. Nevertheless, the difficulties are far from being so insurmountable as is generally believed, and in proof thereof I present the Society some micro-photographs of various kinds obtained in a very simple way by M. Hempel, member of the Belgian Photographic Association. I may remark, in the first place, that the examples are far from representing the best examples which M. Hempel has obtained: on the contrary, they are the first essays made by an amateur which I place before your eyes. With a little more experience of photographic operations much better clichés will be obtained, I have no doubt, than those which are now laid before you.

The manner of operating is as follows,: In any department into which the morning sun enters M. Hempel places his microscope upon a table. The instrument he employs is simply a small one of Hartnack's construction, upright, and bereft of its eyepiece. Above the microscope is fitted vertically, by the aid of a support, an ordinary camera (quarter-plate) capable of taking pictures nine by twelve centimeters, furnished with a focussing glass. The camera is in connection with the microscope by means of a little cone of black cloth, fixed to the photographic apparatus by the metal rim (where the lens fits in) and to the microscope by means of a rubber washer.

The object is put under the microscope in its proper place upon the object stand, and the sun's rays are directed upon it in the usual way by a mirror. The operator looks upon the focussing screen of the camera, and then, by the aid of the screw of the microscope, the enlarged image is focussed. If the image appears too small, it may be enlarged by gradually elongating the body of the camera; or if too big, the reverse operation is performed.

Having determined the size of the image, a diaphragm of very small aperture (about a quarter of a millimeter) is placed under the object, and a slight turn of the screw then furnishes the requisite amount of sharpness: the object may then be said to be focussed. In micro-photography the focussing should be rigorously exact, and a strong magnifier must be employed to view the image upon the ground glass; and to be able to judge the better of the half-tones, the operator should surround his head with a black cloth, to keep away the light. The focus properly adjusted, the operation of photographing may be commenced.

Before going any further, I may here call attention to a grave difficulty which may possibly occur; it is possible that the image may be perfectly sharp upon the ground glass, and yet when the collodion film is substituted there is a lack of sharpness and detail. In this case the operator has to do with a lens in which the chemical focus does not coincide with its optical focus. Nevertheless, the evil is not an irreparable one, and a series of experiments properly undertaken will soon show how much the screw of the microscope should be turned to yield a good result. I may, however, state that I am convinced that defective lenses of this kind are much less freqently met with than is supposed to be the case, and good achromatic lenses always give good images. At the same time, in the case of colorless objects, or such as are of a monotone, like the diatoms, polycystines, and a large number of other organisms, the employment of very achromatic lenses is not indispensable.

In support of what I have just advanced, I may mention that the microscope which M. Hempel makes use of was not chosen for any special purpose, and gives with each of its true lenses pictures which have not the least trace of chemical defect.

The image of the object having been focussed, the latter is covered with a small piece of black cardboard; the ground glass is removed and there is substituted for it the dark slide with the prepared plate. The slide is withdrawn, and by stooping down it is easy to direct upon the diaphragm the little luminous circle formed by the concentration of solar rays by the mirror then, without loss of time, the piece of cardboard is removed from the object for a short time, and again replaced without hesitation. This brief period suffices to impress an image upon the collodion film; the dark slide is drawn, and the plate carried into the dark room to be developed, washed, and intensified if necessary, and finally fixed. From this negative may now be printed an indefinite number of positive forms.

So far as concerns the disposition of the apparatus, I would remark that I do not recommend the vertical arrangement, which M. Hempel is compelled to have recourse to because his microscope is a vertical one. It is better to work with an inclined microscope, which allows one to place the camera in a horizontal position, by which means all the operations are considerably facilitated, and the whole affair assumes a proper stability.

In regard to objects to be reproduced in the micro-camera, two points have to be considered, their thickness and color. As in the case of looking at an object under the microscope, the difficulty is to focus an object in every part, for some portions are sharp, while others are blurred, from the fact that they are not all in the same flame. Nevertheless, the photographic process offers many resources, and it is possible to obtain very extensive enlargements, even with very feeble lenses. To do this, the exposure in the camera should be lengthened, the object, whether opaque or transparent, being always well lighted.

So far as regards color, it is well known that certain of them—such as yellow, red, and green—do not reproduce themselves in photography according to their intensity, and that the prints appear with much darker tones than the originals appear to the eye. In cases where the objects present non-photogenic tints, they should be very powerfully illuminated, but with a very small diaphragm, polarized light being employed with advantage. Many organic substances of brown and yellow color may have their tints reversed, or their outline lighted upon a black ground, by using polarized light.

The photographic process employed in micro-photography should be a very rapid one, and for this reason wet plates are the best; but now that dry-collodion processes, and especially the so-called emulsion methods, have been so much improved in England, these should be particularly applicable to micro-photography. By employing such a process, the operator might prepare in advance a whole series of plates, and these he would merely have to slip into the microscope one after another, in order to secure twenty, thirty, or as many even as fifty photographs of different subjects in one morning.

* Bulletin de la Société Francaise.

BUTTERFLY COLOR.—It has long been supposed that the colors of the butterfly's wings suffer from exposure to concentrated light, and, according to the *Institut*, M. Capronnier has recently been making experiments with a view to ascertaining what sort of light bleaches most strongly. The result arrived at is that, as in photography, after the white light the blue light is the most actinic.

PURPURIN.—Dr. Vogel gives a few details with regard to the sensitiveness to light of purpurin, which has been so much talked-of recently in connection with the sight purpurin of the eye and the recent experiments of Kuhne with the eyes of oxen, rabbits, etc. Purpurin—a dyestuff found along with alizarin in madder—gives a solution which, in the presence of a little alkali, is extraordinarily sensitive to light. Other solutions of dyestuffs, themselves actually more sensitive to light—such as fuchsin, alcanna red, and santalin—do not lose their color after several days' exposure to light. In clear weather a wine-red colored solution of purpurin becomes colorless in about ten minutes; and even by lamp-light, at a distance of twenty centimetres from the lamp, in about half an hour it will be distinctly apparent that the color has begun to fade. Dr. Vogel's former experiments show that in this bleaching its power of absorbing yellow rays plays an important part. An alkaline solution of carmine is also sensitive to light in the same way, though not to the same extent, as the alkaline purpurin solution. Schunk and Römer found that alkaline purpurin also lost its color in the dark, and that when deprived of air it did not bleach either in the light or the dark. It follows from their experiments that oxygen is necessary to the bleaching of purpurin. Any one can, however, convince himself by a simple experiment that purpurin is much more readily bleached in the light than in the dark.

Mix with ten cubic centimetres of distilled water about ten drops of a saturated tincture of purpurin and one drop of ammonia; divide the beautiful rose-colored fluid so obtained into two equal parts, and put each part into a test-tube. Cover one of the test-tubes with black paper, and place both in the window. After the lapse of ten minutes compare the two glasses, when, even if there be only daylight without sunlight, the liquid in the uncovered one will be found to be a good deal bleached, while that in the protected tube will scarcely be changed at the end of a couple of hours.

THE *Mittheilungen* contains Herr Goltzch's third article on the advantages of reviving stereoscopic pictures, this one being devoted to stereoscopic portraits. The same number also contains a statistical account of the number of photographic establishments in Germany—estimated at a little over three thousand—and of the quantities of chemicals they consume, an average of three pounds per establishment being allowed as the consumption of nitrate of silver, and its cost being estimated at about £27,900 sterling. Of this large quantity it is supposed that about sixty per cent., or the value of £16,400, is annually lost in one form or another as waste. The value of the gold salts used is estimated at a quarter or, at most, a third of the sum allowed for silver, that is, at about £9,000 Owing to the quantities of albuminized paper exported through dealers, and of French mounts imported, it has been found almost impossible to assign figures to these last two items. The number of frames made in Berlin—of which, however, only a portion is used in Germany—is stated at an annual product representing £7,500.

BEET ROOT AND BEET ROOT SUGAR.

By EDW. LEFROY CULL.

A MODIFICATION of the diffusion process might, we think, be advantageously used by the farmer as follows. It has never been tried, that the author knows of, but it is a matter of common sense, and, as such, one person can form as good an opinion on it as another: When the ground root is thoroughly pulped mix it with a sufficient proportion of wheat or oat chaff, or clean chopped straw; put in a high tub, possibly six feet deep; sprinkle water on the top, which, percolating through the mass, would, from the well-known laws which govern diffusion of all substances, take out the sweet and other matters from the pulp, and pass off at the bottom of the tub quite as strong or but very little weaker than the juice itself. There must, of course, be a false bottom in the tub, pierced with holes, the juice being allowed to run freely off from the bottom into the boiler. It would come off quite fine and clear. A good arrangement of this plan would be to have a series of tubs, say two feet deep each, the bottoms being all pierced with holes, the tubs just fitting into each other. The number should be six. In the first place fill them all with the mashed root and chaff or cut straw; then pile them up one on the top of the other. The lower one must, of course, stand in a tray. Continue your leaching until the liquor begins to get weak; then, by a convenient arrangement, remove the top vessel, which by this time will be entirely exhausted. Raise the pile of vessels and add a newly-charged tub to the bottom and proceed as before.

This arrangement would save the press, the pressing and the cloths, and be entirely within the farmer's own means. I do not pretend to say that it could be done on the very largest scale, although I am sure it could be done on a small scale with great effect. The spent pulp and chaffed straw might be used a second or even a third time in Winter. It could be used over and over again, until there was a fear that souring or fermentation would commence. The pulp and chaffed straw would be in the most favorable state possible for feeding purposes.

The principle of diffusion is this, in short: When water is mixed with a substance, such as pulp or chopped beet root, which contains a heavy, thick strong juice, the

water enters the substance and displaces the strong juice and remains in the substance at exactly half the original strength of the juice. A second addition of water reduces this again one-half, and a third addition again reduces the strength of the liquor. A fourth addition is supposed to complete the extraction of the original juice, leaving the water in place of the other fluids. Even where the root is cut up into small pieces the same effect takes place, though more slowly. The water then replaces the juice in the cells of the substance, the thick juices pass through the walls of the cells by the process of dialysis, and the water remains.

DEFECATION.

Let us now see how you are to deal with the juice after having obtained it. Whatever way you may obtain it, the juice must be transferred to the boiler at once, and heat applied. The heat must be kept above 140° Fahrenheit, until you have the boiler full, or as nearly as you can safely boil it. Should any accident happen which may delay the heating of the juice add milk of lime to it, which, for a considerable period, prevents all change. Never, however, allow your juices to remain unheated over night. If anything prevents heating lime it at once. It must not be allowed to ferment or sour, and a very few hours' neglect will cause great loss.

As soon as you have brought the juice to a *gentle* boil in the boiler add the milk of lime, little by little, until you see a change. A sort of curling takes place and flakes separate from the clear liquor. The change is such that you cannot mistake it; but it is a matter for experience only. The quality of beets vary in different places, and so does the quality of the lime. All we can say is that the juice must be sufficiently curdled to break on the surface and show clear liquid between cloudy masses. When this is the case, bring the juice again to a very gentle boil. A thick scum will come on it, which should be skimmed off. The remainder of the lime will settle the liquor. The clear must be drawn off and the lime sediment strained. It will strain quite clear through a factory-cotton filter, which is made by the cloth being spread over and fastened to a wide frame. When all the juice is run through, the resulting lime should be sprinkled with water until all the goodness is washed out of it. The sediment then makes a most excellent manure. There is no fear of the limed juice taking harm now, although of course no delay that can be avoided should take before the next operation, which is carbonation and evaporation. This proceeds simultaneously and will be presently described.

THE MILK OF LIME

is made as follow: Twenty ounces of well-burned lime must be carefully slacked in the usual manner. When slacked, add the rest of the water; stir it well until all is dissolved; then pour off the milky liquor through a fine sieve. The imperfectly-burned stone will remain in the sieve. Weigh this, and, by dissolving more lime in another vessel, make up the dissolved lime to twenty ounces to the gallon. If a little stronger it will not signify; but it should not be weaker. The milk of lime should be kept in a well-bunged barrel. If kept *tightly* stopped it will keep any reasonable length of time, but if the air gets to it it absorbs carbonic acid and becomes so weak as to be useless. Lime slacked with water and kept from the action of the air will keep its strength for any reasonable time.

CARBONATION AND EVAPORATION.

The only utensils required for the farmer's use are the following: A good brick chimney, carried to as great a height as the means and circumstances of the operator will allow; the boiler, which should be strong and good, hemispherical at the bottom, like a potash or sugar kettle, with a good broad rim turned over at the top. On this rim, when required, a wooden curb can be constructed which will enlarge the boiler to an extent. This boiler should be set in brickwork, and be connected with the chimney by an iron or brick flue. It is heated with wood. Into this boiler the juice, as expressed or formed, runs and heat is applied. As soon as it is full the milk of lime is added, the contents of the boiler are skimmed, and the clear liquor removed by a syphon or other means. The limy deposit goes into a deep tub, to settle, and the clear is drawn off. The juice thus prepared holds a great deal of lime. Even when quite clear the sugar in the juice forms, with the lime, "sucrate of lime." As you get the clear liquor it is pumped up by a common simple wooden pump to a vessel set at a considerable height above it, and which commands the carbonating tower. The greater the height of the carbonating tower, the more efficient it will be. The small labor of raising the juice by the pump is of no consequence when compared with the other advantages obtained. The bottom of the carbonating tower commands the boiler. The liquor that is let into it from the upper vessel runs from story to story, or rather drips from story to story, exposing an enormous surface both to the action of carbonation and evaporation.

The carbonating tower is constructed entirely of wood. It is a tall box, thirty feet high if possible, and is filled with shelves, each of which is pierced with two-inch center-bit holes, bored to pattern. There are two of these patterns, the holes of one coming opposite the solid spaces of the other, so that a liquid passing from shelf to shelf drips through the holes, and falls on the solid parts, thus splashing and dividing as much as possible. The tower is covered in at the top tightly, and communicates at the top with the chimney, either by an iron stovepipe or other convenient means. You must, however, have a good *tight* throttle valve in this pipe, or be able to remove the pipe and stop the orifice close, when you want to clean the tower, which is done by steam from the boiler.

The bottom of this tower communicates with the carbonating stove, and the result of combustion in this stove (which must be heated either by hard anthracite coal or by charcoal) passes directly out through an iron stovepipe of greater or less length, so as to take out some of the heat to the carbonating tower. The tower and the chimney thus form a good draft in this stove.

The carbonating stove has also a direct communication with the chimney, and there must be a good tight throttle valve or damper in the communication with the tower. A similar throttle valve or damper is placed in the direct communication with the chimney. These valves are for the purpose of turning the draft of the stove either way. When you light the fire with wood, of course a good deal of smoke forms, and this is conducted into the chimney. When the fire has burned up clear, the chimney damper is closed and the other is opened, and thus the carbonic acid gas which results from the burning of the anthracite or charcoal passes in pure enough state through the tower. When you have got your carbonating stove in order and at work, turn on the liquor in the upper tub slowly through the tower. It drips from story to story thus exposing an enormous surface to the action of the carbonic acid gas fumes from the stove, which carbonate the lime in the juice, and turn the caustic lime into the carbonate.

The stories or shelves in the tower are about six or eight inches apart, and if the tower is thirty feet high, and the liquor is not allowed to run too fast, the juice will be thoroughly carbonated by the time it reaches the bottom. It then passes into the boiler or into a receiving-tub, and is pumped back again into the upper vessel, and again passed through the tower, the stove being kept going until the juice is reduced to a thick, treacley substance, and becomes a concrete strong enough to keep for any length of time. It ought to be nearly solid when finished and cold.

The foregoing plan has been tried and found to work well, but a thoroughly practical friend has suggested that the following would be both simpler and act better, inasmuch as it would give a better draught, and draught is everything in this mode of evaporation; and it is quite certain that air, and consequently draught, passes much more freely through large spaces constructed of single holes than in the same area divided up into a number of holes. Both plans are given, and I think with my friend this one is the most available. Construct your tower of a case eighteen by fourteen inches, inside measure, and as high as you can get it. Instead of the pierced shelves put a number of plain shelves, extending three-fourths across the tower, and about eight inches apart. Put these on a gentle slope, so as to run clear and well. The shelves are alternately placed, first on one side then on the other, so that each shelf drips on to the other at about half way on the shelf. The shelves should be made of sheet-iron or slate. The action would be that the liquor would pass from shelf to shelf, and the draught of hot air would pass over each and through the falling drops, thus exposing the greatest possible surface to the action of the air, being less liable to clog and much easier to clean. When a principle is once well understood, parties can adopt their own ideas in carrying it out.

This vessel is cleaned by steam from the boiler. There must be a good, tight-fitting cover to the boiler to keep in the steam, and the steam must then be directed into the tower, all apertures by which it can escape being closed. The steam thoroughly cleanses every part of the utensil, and destroys all sourness. It will be well also, on all occasions when it can be done, to lime the whole machine by turning on from the upper tub weak milk of lime, and letting it run through several times, so as to guard against all sourness and fermentation. All vessels used in a beet-sugar factory ought to be scrubbed and limed every time they are empty. Too much precaution in this way cannot be used.

By this mode of evaporation the heat is never so great as to burn or color the liquor; the whole evaporation goes on at from 160° to 170° Fahrenheit. In carbonating great heat is avoided, and there is no doubt that the lengthened contact of lime at a boiling heat with the juice tends greatly to produce glucose sugar. You must bring the juice to a boil with the lime or it will not clear and curdle, but should be kept at a boiling heat, whilst in contact with the lime, for the shortest time possible. It is also mischievous for the carbonation to take place at other than the lowest heat possible, certainly under the boiling point.

This is really as far as the farmer ought to go in the manufacture. There is nothing here that he cannot do. He has brought the result of his beet-juice into the smallest possible shape, and one in which it is indestructible if made strong enough and free from water. The matter will pay for the barrels and bear carriage as well as wheat or barley or other grain, and, if well made, the sugar-refiners would take any quantity of it at a fair price.—*Boston Cultivator.*

THE PRICES OF NURSERY AND GREENHOUSE PRODUCTS, ABROAD AND AT HOME.

By PETER HENDERSON.

WHILE the price of labor is from one-third to one-half more in this country than in Europe, nearly all the products of the nursery, greenhouse, or garden are sold lower than there, not merely lower, but in a majority of cases at less than half the price. In nursery stock I have the authority of Messrs. Ellwanger & Barry, of Rochester, N. Y., for stating that, in many leading articles in fruit trees, the differences in prices in favor in this country are as follows: In England, "Standard" Apple-trees are quoted at $18 per 100; the same quality are sold here at $12 per 100. Dwarf Pear trees there sell at $35 per 100; here at $15 per 100. Standard Pear, Plum and Cherry-trees average in England $18 per 100; here $15 per 100. Apricots and Nectarines are sold for about same price here as in England, but Peach-trees, which are the sold here at an average of $70 per 1,000, are there sold at $150 per 1,000. The general assortment of ornamental trees and shrubs shows a corresponding average in favor of lower prices here. In greenhouse or bedding plants, the difference in favor of our lower rates here is even greater, both at wholesale and retail. Roses, for example, which are sold lower in Europe than almost anything else, can rarely be purchased at less than $15 per 100; here the same quality averages $12 per 100. Carnations, or Pinks, which are quoted in England as especially low at $20 per 100, are sold here at $12 per 100. Ferns sold here at $8 per 100, are offered at $12 there; Tuberoses and Gladioluses that are sold here at $4, are quoted there at least double these rates, while, to take the average of bedding or greenhouse plants, that may average here $10 per 100 to the trade, are offered to us by the wholesale English houses as especially low, at $12 per 100.

The question arise, how can our nurserymen and florists sell so much lower, and make the business pay—for that they do make it pay quite as well as European growers do, there is but little doubt. The answer to this is the known fact that the high cost of labor has long ago forced us to use our ingenuity in simplifying our work. What we do with the plow, the English gardener still thinks it necessary to do with the spade. What we do with our horse or hand cultivator, he still does with the hoe, and often a very primitive sort of hoe at that. Where we use stakes and labels that are made by machinery, they, in many cases, make them by hand, when a single one, actually, costs as much in labor as do a hundred when made by machinery. When it comes to the manual operations, necessary in the propagating and growing of greenhouse plants, the same waste of labor is apparent. Our average propagator will take off, make, and set in bench, 1,000 cuttings per day; at the rate I saw the propagators of two of the leading establishments in London working, when there a few years ago, I doubt if the average was 200 a day; and when we tell them that some of our crack workmen can place 10,000 rooted cuttings in pots in 10 hours, they honestly think it false, for probably not more than one-third of that number has ever been done in the same time there. I do not wish to be understood that the English gardener cannot move as rapidly as the American can, but custom there clogs his hands with unnecessary work, to accomplish the object desired. The other day a man of 40 years of age presented himself to me, with credentials from a long established Edinburgh firm, stating him to be an experienced propagator and cultivator of plants. To test his capabilities, I handed him a lot of rose cuttings to prepare, every one of which he cut at an eye or joint, in the approved orthodox style of a quarter of a century ago; all propagators of experience here have long known, that this is not only a great waste of material, but a still greater waste of time, and we never do it unless in particular cases that very rarely occur. I might mention scores of similar operations which are performed abroad in a manner which seem to us as primitive as this.

The adage, that "A prophet is not without honor, save in his own country," is true in this matter as in many others; for we find that most Americans having horticultural tastes, when visiting Europe, buy largely there, their plants costing them, when duties are added, three times as much for half dead trees or plants, as they would pay at home for healthy ones. It is often the case, especially with fruits, that the varieties purchased are utterly useless for our climate. For example, the Jargonelle Pear, Ribston Pippin Apple, and Keen's Seedling Strawberry, still hold a first place in the English gardens, while experience has shown them to be worthless here. So with many ornamental trees; beautiful as are the varieties of English Holly and Rhododendrons, hundreds of Americans have poured down anathemas on the heads of European nurserymen for selling them plants as "hardy," that the frosts of our northern States or the hot sun of the South utterly destroy the first season.—*American Agriculturist.*

HAYMAKING.

HAY should come as near as possible to dried green grass. Haymaking consists essentially in evaporating the water from grasses cut in a succulent stage, and should be confined to this alone, while the best hay will be made by those who realize that the process is simply treating grass so that it may be stored with safety. If it were possible to expose every blade of grass as soon as cut to a temperature of 200° for a few hours, and then pack under a water-proof roof, the hay would be as good as the grass could yield. The nearer the farmer's haymaking approaches this result the better will be his crop.

Out of the constitutents of which grass is composed the mucilage, starch, gluten and sugar are alone of any nutritive value; the woody fibre serves only to give bulk to food, thereby assisting animal digestion. The main object of haymaking is to retain these nutritive elements, all of which are soluble in water and easily assimilated. This is very imperfectly done even by the most approved methods, since the 387.5 pounds of grass, that are required to make 100 pounds hay, contain 28.13 parts soluble in hot water, and 8.21 parts in cold water, while its equivalent in the 100 pounds of hay contains only 16 parts soluble in hot water, and only 5.06 parts in cold water, thus showing a great loss of nutritive matter in the drying process. This is illustrated by the fact that a cow, thriving for a certain period on 100 pounds of green grass, cannot receive the same benefit from its equivalent, or 25 pounds of hay, without the addition of grain food.

Hay should not be too long exposed to the rays of the sun, because this excessive drying and baking effects the conversion of starchy soluble substance into indigestible woody fibre after the hay is cut; hence the more quickly the drying is effected the less extensively will such changes take place. It is also desirable to preserve its green color and peculiar fragrance, and simply dry it so that as little heating or fermentation as possible shall occur in the mow. Moderate sweating in the mow, or such heating as is produced by the sap remaining after the principal moisture has been removed, improves the quality of the hay, because it has the effect of rendering the fibres of the grasses more tender and of changing part of the pithy matter into sugar, on the same principle as is effected in the malting of barley, giving a sweet taste very palatable to horses and cattle.

The main point is to protect the hay from dew or rain; water washes away the soluble salts and other nutritive matters, since in every ton of good hay there are one hundred pounds of valuable elements soluble in cold water and over three hundred pounds in hot water. Avoid housing any wet hay, as the water will cause fermentation in the mow and destroy some of the most valuable properties. Avoid hauling to the barn, or even cocking hay, after nightfall, and never open hay-cocks in the morning until the dew has evaporated. If the weather is unfavorable the less hay is disturbed the better; hay will preserve a great part of its nutritive qualities for many days when mown wet or saturated with rains whilst lying in the swarth and not stirred. If repeatedly dry and wet it will soon become valueless. It is folly to meddle with hay amid frequent showers, as it is far better to have it somewhat tainted in the hay-cock than bleached and exhausted of its nutriment and spoilt by frequent attempts at spreading.

The tendency of the age is toward more rapid harvesting of the hay crop. Inventive genius has brought nearer to perfection the machinery by which the various operations may be much hastened, and experience has proved that, after all, the hay that was made and put in during the daylight of some single, bright, and sunny day was vastly superior in feeding and marketing qualities to that which was subjected to heat and air enough to give it the appearance and name of grass-straw. The same rules cannot be applied to all growths, since coarse grass requires less making than fine, succulent herbage, and clover needs curing in the cock. No hay should be so dry as to be brittle when twisted in the hand.

As a rule, especially in years past, farmers have dried their hay too much, and, could all such realize that one ton of properly-cured hay, with its constituent parts well retained, with its aroma and green color well preserved, was worth, for feeding purposes, two tons of the yellow, odorless, and flavorless product that too often is the result of the season's labor, a change of system in haymaking would occur this very Summer, that would add millions of dollars to the value of the hay crop of America.—*Boston Cultivator.*

IVY will succeed better in our warm, dry rooms than any other plant, and all that is needed to make it attractive is the exercise of a little ingenuity in the appliances for its home. It will not grow quite as well in strong light, as when partially shaded, as the ivy loves shade and an even, cool atmosphere.

INDIAN CORN AS FOOD FOR MAN.

Corn is the most widely-cultivated grain in the world with the exception of rice. The three great articles of human food are wheat, corn and rice. Wheat is principally produced in temperate countries and is not grown to a large extent in very hot regions; rice is the product and food of hot countries only; while corn, though a tropical plant, grows equally as well in such temperate regions as have a sunny clime. The warmest regions of the torrid zone produce corn in abundance, giving three crops in a single year; and yet so short is the season required for its development that even the hot sun of Canada's limited Summer suffices to bring it to perfection.

As to nutritive matter corn is only exceeded by wheat and followed by rice among the leading articles of food. Indian meal contains less water than wheat flour, more albumen, four times the quantity of fat, more nitrogen and available carbon, an equal quantity of salts, and is slightly deficient in starch, and still more so in sugar. On account of its lack of gluten it is not well adapted for making bread without a slight admixture of wheat or rye flour, but for cakes, to be eaten soon after cooking, for puddings and the like, it is very palatable. Calculated according to the physiological wants of the system, a week's diet for an adult would only cost about twenty cents, and, excepting split peas, there is nothing approaching corn for economy. Corn meal would be more extensively used among all classes if its manufacture was conducted with as much skill and care as is devoted to wheat and oats, and if it could be obtained pure and sweet, and that man will be a public benefactor who shall devise some method of presenting its nutritious qualities in a palatable and accepted form.

Even in the United States, where thirty-seven million acres are devoted to the culture of Indian corn, yielding a total product of thirteen hundred million bushels, while the wheat crop of the world is only seven hundred and sixty million bushels, we only understand the economic value of corn as cattle food, as a prime factor in prime beef and a plentiful supply of pork. In this respect even we are groping in the dark, for no thorough analyses of our varieties of corn have ever been made; and while some kinds are far more desirable than others even as food for man, our knowledge on the subject is extremely limited. Granting for argument's sake that wheat contains eighteen per cent more nutritive matter than corn, then if a bushel of wheat is worth one dollar, the same weight of corn should sell at eighty-two cents; yet to-day, while the average price of wheat at the seaboard is two dollars per bushel, that of corn is sixty-five cents. Either wheat is too high or corn is too low. In buying wheat flour the same outlay would purchase double the amount of nutriment in Indian meal.

The prejudice against the use of corn as an article of human food is based on ignorance in many cases, and on false pride in others. Wheat is most agreeable to the taste, and is preferred by a greater portion of the human family, or, at least, by those who are able to purchase it. While all the world is familiar with wheat as an article of food, not one-tenth of its population ever heard of Indian corn except as cattle food. It is quite remarkable that notwithstanding its acknowledged good qualities and its economy, yet it is but little known to the people of those portions of Europe to whom cheap food is an absolute necessity; and even in times of famine it has required judicious and persistent governmental efforts to induce famishing communities to use it. The introduction of Indian corn has been comparatively slow, since it seems difficult to displace wheat so long as it can be obtained; yet it is certain that a few years hence will witness an enormous demand, resulting from a popular appreciation of this cheap and wholesome staple, and a diminished purchasing power among the masses in Europe.

England imports 75,000,000 bushels annually at a cost of $51,000,000; India is raising enormous quantities, now universally consumed as human food; Brazil cultivates the crop largely, esteeming it nutritious and wholesome; Italy annually raises 45,000,000 bushels; Austria, 80,000,000 bushels; Hungary, 66,000,000; France, 30,000,000; Portugal, 15,000,000; Greece, 3,000,000; New South Wales, 1,000,000. Since the famine of 1846 in Ireland, its use is established in Great Britain. Germany is annually consuming increased quantities; it enters largely into the food of America, Natal, Italy, Spain, the south of France, the Danubian principalities, Mexico, Africa, Turkey, Egypt, India, China, and many other nations. Forming so large an element in our annual crops, and possessed of a soil and climate unrivalled in its production, Indian corn will in the near future assume still greater proportions as an article of American growth and export.—*Boston Cultivator.*

[Scientific Farmer.]

UTILIZATION OF DEAD ANIMALS.

During the winter quite a large number of my domestic animals died, and the work of composting was at once begun. The *modus operandi* was as follows: A convenient location being first selected, the site of the compost was prepared by throwing the soil up to the height of 8 or 10 inches. The dead animals being first skinned, the flesh and bones were cut up into small pieces with knives and axes. The formation of the compost was then commenced by putting down a layer of wood mould to the depth of about six inches. Then followed a layer of bones and flesh, and upon this was added six inches of strong, fresh stable manure; then another layer of wood mould, and so on until the job was finished. The several additions that were afterwards made to the heap as an animal died were done in the same way, and the whole was secured from the depredations of hogs and dogs by a high rail fence. In the spring, when ready to haul out this compost, having to leave home for a day or two, I directed my hands to take care of all the bones, intending to get some sulphuric acid to decompose them with. When I returned home I went to the compost, where the hands were still employed in carting it to the field. I enquired of them what had been done with the bones. They replied that only a very small quantity had been found; less than a peck. Upon examination of what was left of the heap I found that the bones had been almost entirely decomposed. Since that time I have been in the habit of making compost of all my dead animals, with similar results. They make a most excellent manure and a great deal of it. A large, fat horse will make from ten to twelve loads. Generally it takes about three months to decompose the bones when thus composted; but when the animals are young and the bones tender, it may be done in six months. Ten years ago I lost a young ox about April 1st; I had it put in a compost, and about the 15th of May I found the bones entirely decomposed. I am in the habit of gathering up all the bones from the household and on the farm, and composting them in like manner with the dead animals, first breaking them up into small pieces.

William Holman.

[Nature.]

JAPANESE MIRRORS.

A short time ago a friend showed me a curious effect, which I had previously heard of, but had never seen. The ladies of Japan use, in making their toilet, a small round mirror about $\frac{1}{16}$ to $\frac{1}{4}$ inch in thickness, made of a kind of speculum metal, brightly polished and coated with mercury. At the back there are usually various devices, Japanese or Chinese written characters, badges, etc., standing in strong relief, and brightly polished like the front surface. Now if the direct rays of the sun are allowed to fall upon the front of the mirror and are then reflected on to a screen, in a great many cases, though not in all, the figures at the back will appear to shine through the substance of the mirror as bright lines upon a moderately bright ground.

I have since tried several mirrors as sold in the shops, and in most cases the appearance described has been observed with more or less distinctness.

I have been unable to find a satisfactory explanation of this fact, but on considering the mode of manufacture I was led to suppose that the pressure to which the mirror was subjected during polishing, and which is greatest on the parts in relief, was concerned in the production of the figures. On putting this to the test by rubbing the back of the mirror with a blunt pointed instrument, and permitting the rays of the sun to be reflected from the front surface, a bright line appeared in the image corresponding to the position of the part rubbed. This experiment is quite easy to repeat, a scratch with a knife or with any other hard body is sufficient. It would seem as if the pressure upon the back during polishing caused some change in the reflecting surface corresponding to the raised parts, whereby the amount of light reflected was greater; or supposing that of the light which falls upon the surface, a part is absorbed and the rest reflected, those parts corresponding to the raised portions on the back are altered by the pressure in such a way that less is absorbed, and therefore a bright image appears. This, of course, is not an explanation of the phenomenon, but I put it forward as perhaps indicating the direction in which a true explanation may be looked for.

The following account of the manufacture of the Japanese mirrors is taken from a paper by Dr. Geerts, read before the Asiatic Society of Japan, and appearing in their *Transactions* for 1875–76, p. 39:

"For preparing the mould, which consists of halves, put together with their concave surfaces, the workman first powders a kind of rough plastic clay, and mixes this with levigated powder of a blackish 'tuff-stone' and a little charcoal powder and water, till the paste is plastic and suitable for being moulded. It is then roughly formed by the aid of a wooden frame into square or round cakes; the surface of the latter is covered with a levigated half-liquid mixture of powdered '*chamotte*' (old crucibles which have served for melting bronze or copper) and water. Thus well prepared, the blackish paste in the frame receives the concave designs by the aid of woodcuts, cut in relief. The two halves of the mould are put together in the frame and dried. Several of these flat moulds are then packed in a melting box made of clay and 'chamotte.' This box has on the top an opening, into which the liquid bronze is poured, after it has been melted in small fire-proof clay crucibles. The liquid metal naturally fills all openings inside the box, and consequently also the cavities of the moulds. For mirrors of first quality the following metal mixture is used in one of the largest mirror foundries in Kiôto:

Lead	5	parts.
Tin	15	"
Copper	80	"
	100	

For mirrors of inferior quality is taken:

Lead	10	parts.
Natural sulphide of lead and antimony	10	"
Copper	80	"
	100	

* * * * * * *

"After being cooled the melting box and moulds are crushed and the mirrors taken away. These are then cut, scoured, and filed until the mirror is roughly finished. They are then first polished with a polishing powder called *to-no-ki*, which consists of the levigated powder of a soft kind of whetstone (*to-ishi*) found in Yomato and many other places. Secondly, the mirrors are polished with a piece of charcoal and water, the charcoal of the wood *ho-no-ki* (*Magnolia hypoleuca*) being preferred as the best for this purpose. When the surface of the mirror is well polished it is covered with a layer of mercury amalgam, consisting of quicksilver, tin, and a little lead. The amalgam is rubbed vigorously with a piece of soft leather, which manipulation must be continued for a long time until the excess of mercury is expelled and the mirror has got a fine, bright, reflecting surface."

R. W. Atkinson.

University of Tokio, Japan.

Paper from Cactus.—The *Greeley Tribune* tells us that the manufacture of paper of excellent quality from the species of Cactus growing in great abundance in the Mojava Desert, has recently been tested at the Lick paper mill, at San José, by parties interested, who propose, if possible, to obtain control of all the paper mills on the coast, and set them in operation on this material exclusively. The Cactus paper is said to be very strong, and the supply of material unlimited.

HOW TO MAKE RUBBER HAND STAMPS.

D. says: In answer to several correspondents who wish to know how to make rubber hand stamps: Vulcanized rubber is used, as prepared, by the manufacturers, and can be procured in strips about 3 inches wide and about ⅛ of an inch thick and of any desired length. The name and address should be set up in common printing type and the type well oiled: a rim about ½ inch in hight should be placed around the form, and dentist's plaster, mixed to the proper consistence, poured in and allowed to set; then the plaster cast is separated from the type. A piece of the soft vulcanized rubber is then cut of the size of the plaster mold, and laid upon it, and both together are placed in a screw press, and heat sufficient to thoroughly soften the rubber is applied. The screw is then turned down hard and left for a short time until the rubber is perfectly forced into the mold.

After the whole is cold, the rubber is separated from the model, and any irregularities trimmed off with a sharp knife; the rubber stereotype is then fastened, with glue or other cement, to a block of wood, and the stamp is ready for use.

ORNAMENTAL CHAIRS. DESIGNED BY BERNH. LUDWIG, VIENNA.—(*From the Workshop.*)

To Oxydize Gold, Silver, or Brass.—Paint over the parts to be oxydized with a solution of chloride of platinum, then let it dry. To make the chloride of platinum in solution dissolve one drachm in two ounces of hot water.

An alloy of 100 parts of aluminium and 5 of silver can be worked like pure aluminium, but is harder and susceptible of a beautiful polish. An alloy of 100 parts of silver and 6 of aluminium is nearly as hard as ordinary silver, but has the advantage over it of containing no metal of a poisonous nature or which can effect a discoloration of the silver.

In the disputed fire case of the Aldine company of New York, disappearance of electrotype plates was accounted for by a remarkable illustration of the fusibility of the type metal. According to the report, a fine powder rejected by insurance men as ashes, was 35 per cent. lead. The antimony of the alloy possibly passed off in fumes of antimonic oxide.

THE ART OF PRINTING.

The four hundredth anniversary of the early printer's invention was celebrated with more enthusiasm at Montreal this year than at any other place on the continent. Addresses were delivered June 27th by Principal Dawson, Hon. Mr. Chameau, and Mr. T. White, Jr. A large collection of old and rare books and prints and coins had been made in Mechanics' Hall, comprising quite a museum of antiquities. There was a large folio copy of the Decretum Gratiani, printed in Strasbourg by Henry Eggestein, an apprentice of Guttenberg, in 1472; a copy of Caxton's Dictes and Sayings of the Philosophers, 1477; and one of his Polychronian, 1482; a copy of Tulley's Offices, printed by Wynkyn de Worde in 1534. Other curiosities were Law Statutes of Henry VII, printed by Richard Pynson, 1510, Vitas Patrum, Wynkyn de Worde, 1495, and Grammatical Primæ Partes, same printer, 1533. There were also 533 specimens of the art previous to 1650, and 480 subsequent to that date. The Mazarin Bible, printed in 1455 by Guttenberg himself, a book printed by Faust in 1459, and a copy of Eliot's Indian Bible, attracted great attention for their rarity and antiquity.